International Virtual Conference on Materials and Nanotechnology
In Association with International Journal of Scientific Research in Science and Technology
Volume 9 | Issue 4 | Print ISSN: 2395-6011 | Online ISSN: 2395-602X (www.ijsrst.com)

Applications of Nanotechnology in Diabetes - A Review

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ABSTRACT

Nanotechnology is an advanced scientific technique that provides more accurate and timely medical information for diagnosing disease. Diabetes mellitus (DM) is a commonly seen chronic disease, which seriously threatens the health of human beings. About 150 million people suffer from diabetes in the world and it has been predicted that this number will be doubled within 15 years. Nanotechnology is a focal point in diabetes research, where nanoparticles in particular are showing great promise in improving the treatment and management of the disease. Nanotechnology can now offers new implantable or wearable sensing technologies that provide continuous and extremely accurate medical information. The purpose of this is to throw more light on the recent advances and impact of nanotechnology on biomedical sciences to cure diabetes. Nano medicine, the application of nanotechnology to medicine, has already offered some new solutions, and many pharmaceutical companies are trying to develop targeted drug delivery using nanotechnology and already existing drugs. Nanotechnology offers some new solutions in treating diabetes mellitus. This review concluded that nanotechnology will be effective therapy in diabetes.

Keywords : Nanotechnology, Diabetes, Nanoparticles, Nanomedicine, Nanospheres.

I. INTRODUCTION

Diabetes mellitus, often simply referred to as diabetes—is a group of metabolic diseases in which a person has high blood sugar, either because the body does not produce enough insulin, or because cells do not respond to the insulin that is produced. This high blood sugar produces the classical symptoms of polyuria (frequent urination), polydipsia (increased thirst) and polyphagia (increased hunger)[1] ¬ . There are three main types of diabetes:

- Type 1 diabetes: results from the body's failure to produce insulin, and presently requires the person to inject insulin
- Type 2 diabetes: results from insulin¬ resistance, a condition in which cells fail to use insulin properly, sometimes combined with an absolute insulin deficiency.

Gestational diabetes: is when pregnant¬ women, who have never had diabetes before, have a high blood glucose level during pregnancy. It may precede development of type 2 DM. Other forms of diabetes mellitus include congenital diabetes, which is due to

genetic defects of insulin secretion, cystic fibrosis-related diabetes, steroid diabetes induced by high doses of glucocorticoids, and several forms of monogenic diabetes. All forms of diabetes have been treatable since insulin became available in 1921, and type 2 diabetes may be controlled with medications. Both type 1 and 2 are chronic conditions that usually cannot be cured. Pancreas transplants have been tried with limited success in type 1 DM; gastric bypass surgery has been successful in many with morbid obesity and type 2 DM [2] . Gestational diabetes usually resolves after delivery. Diabetes without proper treatments can cause many complications. Acute complications include hypoglycemia, diabetic ketoacidosis, or nonketotic hyperosmolar coma. Serious long-term complications include cardiovascular disease, chronic renal failure, retinal damage. Adequate treatment of diabetes is thus important, as well as blood pressure control and lifestyle factors such as smoking cessation and maintaining a healthy body weight [3]

II. USE OF NANOTECHNOLOGY IN THE DETECTION OF INSULIN AND BLOOD SUGAR

A new method that uses nanotechnology to rapidly measure minute amounts of insulin and blood sugar level is a major step toward developing the ability to assess the health of the body's insulin-producing cells. It can be achieved by following ways.

BY MICROPHYSIOMETER:

The microphysiometer is built from multiwalled carbon nanotubes, which are like several flat sheets of carbon atoms stacked and rolled into very small tubes. The nanotubes are electrically conductive and the concentration of insulin in the chamber can be directly related to the current at the electrode and the nanotubes operate reliably at pH levels characteristic of living cells. Current detection methods measure insulin production at intervals by periodically collecting small samples and measuring their insulin levels. The new sensor detects insulin levels continuously by measuring the transfer of electrons produced when insulin molecules oxidize in the presence of glucose. When the cells produce more insulin molecules, the current in the sensor increases and vice versa, allowing monitoring insulin concentrations in real time [4].

BY IMPLANTABLE SENSOR :

Use of polyethylene glycol beads coated with fluorescent molecules to monitor diabetes blood sugar levels is very effective in this method the beads are injected under the skin and stay in the interstitial fluid. When glucose in the interstitial fluid drops to dangerous levels, glucose displaces the fluorescent molecules and creates a glow. This glow is seen on a tattoo placed on the arm. Sensor microchips are also being developed to continuously monitor key body parameters including pulse, temperature and blood glucose. A chip would be implanted under the skin and transmit a signal that could be monitored continuously.

III. USE OF NANOTECHNOLOGY IN THE TREATMENT OF DIABETES

Diabetes is considered to be one of the major afflictions of modern western society. To date, diabetic patients control their blood-sugar levels via insulin introduced directly into the bloodstream using injections. This unpleasant method is required since stomach acid destroys protein-based substances such as Insulin, making oral insulin consumption useless. The new system is based on inhaling the insulin (instead of injecting it) and on a controlled release of insulin into the bloodstream (instead of manually controlling the amount of insulin injected) [5]. The treatment of diabetes includes the proper delivery of insulin in the blood stream which can be achieved by nanotechnology in the following ways:

DEVELOPMENT OF ORAL INSULIN:

Production of pharmaceutically active proteins, such as insulin, in large quantities has become feasible [6, 7]. The oral route is considered to be the most convenient and comfortable means for administration of insulin for less invasive and painless diabetes management, leading to a higher patient compliance [8]. Nevertheless, the intestinal epithelium is a major barrier to the absorption of hydrophilic drugs, as they cannot diffuse across epithelial cells through lipid-bilayer cell membranes to the bloodstream [9]. Therefore, attention has been given to improving the Para cellular transport of hydrophilic drugs [10, 11]. A variety of intestinal permeation enhancers including chitosan (CS) have been used for the assistance of the absorption of hydrophilic macromolecules [12]. Therefore, a carrier system is needed to protect protein drugs from the harsh environment in the stomach and small intestine, if given orally [13]. Additionally, CS nanoparticles (NPs) enhanced the intestinal absorption of protein molecules to a greater extent than aqueous solutions of CS in vivo [14]. The insulin loaded NPs coated with mucoadhesive CS may prolong their residence in the small intestine, infiltrate into the mucus layer and subsequently mediate transiently opening the tight junctions between epithelial cells while becoming unstable and broken apart due to their pH sensitivity and/or degradability. The insulin released from the broken-apart NPs could then permeate through the Para cellular pathway to the bloodstream, its ultimate destination.

MICROSPHERE FOR ORAL INSULIN PRODUCTION:

The most promising strategy to achieve oral insulin is the use of a microsphere system which is inherently a combination strategy. Microspheres act both as protease inhibitors by protecting the encapsulated insulin from enzymatic degradation within its matrix and as permeation enhancers by effectively crossing the epithelial layer after oral administration [15].

ARTIFICIAL PANCREAS:

Development of artificial pancreas could be the permanent solution for diabetic patients. The original idea was first described in 1974. The concept of its work is simple: a sensor electrode repeatedly measures the level of blood glucose; this information feeds into a small computer that energizes an infusion pump, and the needed units of insulin enter the bloodstream from a small reservoir [16]. Another way to restore body glucose is the use of a tiny silicon box that contains pancreatic beta cells taken from animals. The box is surrounded by a material with a very specific nanopore size (about 20 nanometers in diameter). These pores are big enough to allow for glucose and insulin to pass through them, but small enough to impede the passage of much larger immune system molecules. These boxes can be implanted under the skin of diabetes patients. This could temporarily restore the body's delicate glucose control feedback loop without the need of powerful immunosuppressant that can leave the patient at a serious risk of infection [17].

THE NANOPUMP:

The Nano pump is a powerful device and has many possible applications in the medical field. The first application of the pump, introduced by DE biotech, is Insulin delivery. The pump injects Insulin to the patient's body in a constant rate, balancing the amount of sugars in his or her blood. The pump can also administer small drug doses over a long period of time [18]

IV. CONCLUSION

Nanotechnology can be defined as the monitoring, repairing, construction and control of human biological systems at the cellular level by using

materials and structures engineered at the molecular level. It is useful in detection of insulin and blood sugar by the help of microphysiometer and implantable sensors. By using nanotechnology the nanoparticles were formed and these nanoparticles are also useful in treatment of diabetes. Hopefully, the new kind of treatment may help in making the everyday lives of millions of diabetes patients more tolerable.

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