Current Trends in Pharmaceutical Research, 2022Vol 9 Issue 1
 www.dibru.ac.in/ctprISSN: 2319-4820 (Print)
2582-4783 (Online)

Review article

MICROCHIP: A FUTURISTIC DRUG DELIVERY SYSTEM

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Abstract

The microchip drug delivery system is the most amazing way to distribute a medicine for an extended period of time without the need for the patient to intervene. It comprises of a variable number of drug-filled sockets (usually 50-300) that release the medicine at predetermined times. Using micro fabrication number of reservoirs may be created on a single microchip. The chemical that will be given is injected into the reservoir. Multiple chemicals or other molecules in varying doses can be stored in the reservoir. Several trials have been conducted in recent years to improve medication delivery productivity and to discover a reliable technique for medication delivery within the body. Despite the fact that the controlled release system is the most important drug delivery technology, there has been a surge in interest in micro drug delivery systems for hormones, vaccines and anticancer drugs.

Keywords: Drug delivery, Microchip, Future prospect

Introduction

The most amazing method for administering a medication over a long period of time without the patient's involvement is the microchip medicine delivery system. It consists of many (usually between 50 and 300) drug-filled slots that release medicine at predetermined intervals. Basic drug delivery on microchips involves hermetically sealing small amounts of medication in micro-reservoirs and releasing it on demand or in accordance with a schedule. The storage and long-term preservation of the chemical, as well as correct distribution (i.e., timing and pharmacokinetics), and specific amounts of a chemical delivered at specified

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periods, are all important factors to take into account when administering drugs. A microchip system may store a lot of medications or chemicals and control when and how much of them are released[1]. A drug delivery system that is implanted in the body of a person can distribute a variety of medications in a regulated, pulsatile, or continuous manner.The microchip may be controlled by a computer by attaching it to a small power supply. A microprocessor, a remote control, or biological biosensors. [2]

It used to be a big deal to synthesize or discover novel chemical compounds. entities with therapeutic potential but no pharmacological characteristics. Reduced adverse side effects in pharmaceutical development was one of the study's main objectives. Drug absorption rate and extent have been demonstrated by pharmacokinetic and pharmacological research [3]. Ultimately, therapeutics are governed. In the treatment of systemic diseases, absorption rather than dosage is ultimately in control (Urquhart et al., 1984). As a result, effective ways for delivering medications have been developed. pharmacological selectivity that is not only reliant on chemical properties but also on the controlled rate delivery of a medication (Goldman 1982; Banerjee & Robinson, 1991) [4].

Utilizing traditional techniques, drug release profiles were found (oral dose forms, aerosols, injections, etc.) Creams, lotions, and ointments have a spike in drug concentration shortly after administration, which is followed by a linear or parabolic drop in drug concentration over time. This type of release profile is often adequate when the therapeutic medication concentration is high. With time, the range widens or becomes almost constant. However, it can be found in a number of illnesses. Controlling the release of medications with more accuracy would be desirable and, for certain situations, crucial. [3]

An increasing amount of attention is being paid in recent years to improving the effectiveness of pharmaceutical administration. Pharmaceutical needs are expected to increase. The earth will benefit from modes of delivery globally. Regardless of the fact that the most effective medication delivery strategy presently in use is controlled release. This method of distributing tiny medicine delivery devices has drawn a lot of interest [5]. Examples include hormones, cancer treatments, and immunizations. Prompt medical breakthroughs necessitate speedy replies. Nowadays, medications are given in a different method. Lower side effects, medicine delivery accuracy, and ease of use all improve patient care, lower costs, and convenience of usage. The importance of comfort is paramount [6].

OVERVIEW OF CONTROLLED DRUG DELIVERY

Whether the problem is temporal, spinal, or both, a controlled release mechanism can provide some therapeutic control. In other words, the system aims to keep medicine concentrations in the target tissue under control. Materials or equipment that enable a chemical's release timing, rate, or both may be regulated are referred to as controlled release [1]. The therapeutic efficacy of a drug can be significantly impacted by the way it is delivered. Some medications have a concentration range where they work most effectively therapeutically. Too much or too little of a drug might be dangerous or useless as a treatment. Traditional drug delivery methods often include a rapid increase in concentration that peaks outside of the therapeutic range [7].

The concentration then drops very quickly until the medicine is below the therapeutic range. The time spent in the ideal concentration range may thus be constrained. The use of medication delivery techniques in the past has not been successful in ensuring that the medicine only reaches the appropriate tissues. To aid with the achievement of these objectives, the field of controlled medicine distribution enters the picture. First, by applying the treatment directly to the tissue, an infection can be prevented from spreading to other parts of the body. Second, because controlled drug release is more effective, less medication is needed, which lowers the cost of care. Third, it makes it possible for higher localized concentrations, leading to more successful therapy [8].

The rate and timing of different chemical compounds' release are controlled by microchips, which are provided. In order to treat a range of disorders, researchers will continue to hunt for a method of delivering minute doses of diverse medications in a controlled setting [9]. An improved drug delivery system for such circumstances was developed by Santini and colleagues as a controlled release microchip. Because many disorders necessitate that drugs be administered at various rates, possibly more than once at once, a silicon microchip has been created that satisfies these criteria. The compact size, tightly controlled drug release, and ability to carry out many tasks at once are just a few of the features of the product that enable it solve many of the pharmacological challenges of today. Microfabrication, a technique used to create computer microprocessors, is employed to create the chip. UV photolithography, chemical vapor deposition (CVD), electron beam evaporation, and reactive ion etching are a few of the processes that set them apart [10].

IMPLANTABLE CONTROLLED DRUG DELIVERY

Drugs can also be delivered to body parts that cannot be accessible by conventional drug delivery techniques due to immunological isolation using implantable controlled drug delivery devices. Consider the cornea as an illustration. Implanted drug delivery systems are being used more often to take advantage of peptides' therapeutic potential [11]. Each microchip includes a variety of distinct reservoirs from which dose administration may be controlled by telemetry. Although oral administration is preferred, the limited oral bioavailability of the majority of therapeutic macromolecules demands the use of alternate delivery methods. A microchip-based drug delivery implant controls access to the medicine stored in one or more reservoirs using integrated circuits and related software. Individual components include things like mechanical parts, sensors, actuators, and other electronics. [12]

Data storage may be done via subdermal implants that include microchips. Examples of information accessible by implants include a person's identification, medical history, medication list, allergy list, and contact details. Devices that distribute medications using MEMS may have several limitations that can be reduced [13]. It gives you a lot of dosing flexibility on a variety of levels. Programmable electrical impulses enable the created drug to access the physiological area and start its release. The chemical and physical properties of (for instance) a drug-containing polymer-based matrix may affect drug pharmacokinetics if the dosage form restricts drug availability [14].

MECHANISM OF ACTION

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The chip's operation is simple. Electro capillarity and electrophoresis are used to operate electrically controlled droplet-based laboratories on a chip. A high level of micro fluidic mechanics is required for the manipulation of electrified droplets [16]. Within the unified framework of droplet electro hydrodynamics, we examine these operational ideas, particularly electro wetting on dielectric (a kind of electro capillarity) and electrophoresis. Their electric sources and energy transmission systems serve as differentiators.

The results show that droplet production and manipulation are benefited by dielectrophoresis as well as electro wetting on dielectric. The study included simulations of electrically driven droplet formation, translocation, fusion, and fission. The creation of a soluble gold chloride chemical . If this is the anode potential, gold dissolution can continue. When the thin gold barrier melts, the medication may enter the circulation and travel to its intended location in the body. [17,18].

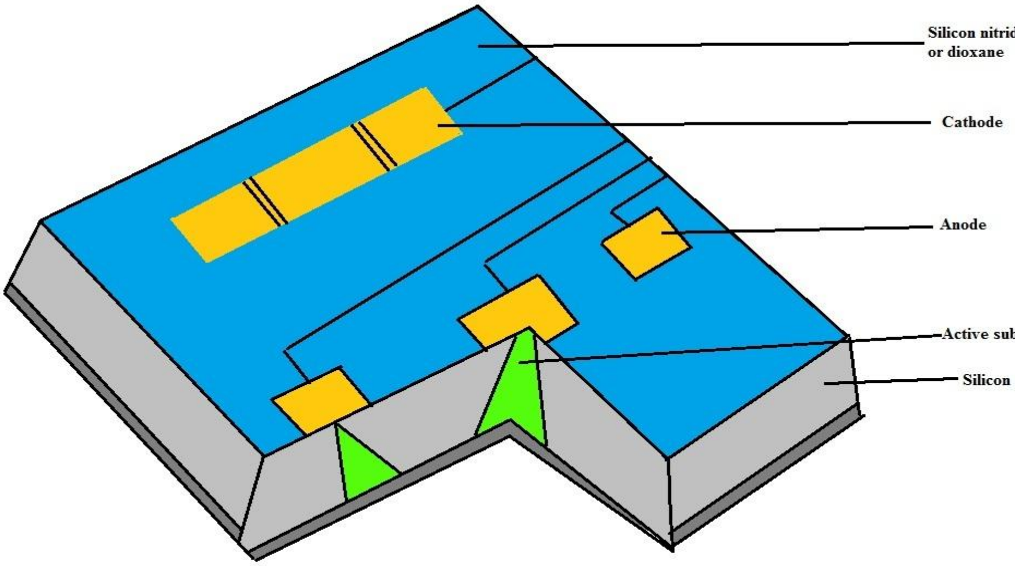

FIGURE1: SCHEMETIC DIAGRAM OF MICROCHIP

APPLICATIONS

1. DNA chips to aid in the diagnosis of brain tumors

Current approaches for treating brain tumors are complex and demanding due to their heterogeneity and fluctuating aggressiveness. Adult gliomas are the most prevalent brain tumors, and their diagnosis is dependent on microscopic features. There is presently no differentiating marker or genetic profile that can predict how each form of glioma will progress [19]. A team of scientists from the Institute Curie and Inserm employed DNA chip technology to find tumors with the greatest prognosis that have a specific chromosomal deletion. Comparative Genomic Hybridization (CGH), one of these analytical methods, enables a global assessment of the genome. Rearranging genomic regions that have been enlarged or deleted, which frequently happens in cancer cells, is how it works. [20]

2. In Cancer Therapy

Doctors utilize protein levels in the blood to gauge the health of elderly patients with chronic diseases and to predict their risk of developing cancer. However, the current methods for identifying these proteins need much too much blood and are too expensive to use often. The researchers wanted to make bedside diagnostics based on blood proteins a reality by making such tests less expensive. [21]

3. Microchip for Antidepressants

The fourth leading cause of disability worldwide is depression. Recently, mechanical devices have been developed, such the microprocessor-based Medication Event Monitoring System (MEMS). The blood test for medicine and its metabolites shows noncompliance for a period of 48 hours or more when the ratio of nordothiepin: dothiepin is greater than 1.1. The MEMS technology allowed us to precisely track the reservoirs' opening times. The main advantage of implanted devices in cases of severe depression is that patients can skip months or even years of taking their medicine. [22]

4. Microfluidic cell treatment

Microfluidic devices allow for the manipulation of individual cell-sized objects, allowing for study in a controlled but physiological setting. Furthermore, parallelizing applicable techniques allows for the observation of a large number of cells at the same time and under identical conditions. [23]

5. Simplicity of release mechanism

Membrane disintegration allows chemicals to escape from the microchip. When an electric potential is given to the membrane, it shatters, causing the membrane to disintegrate by a simple electrochemical process. On the microchip device, there are no moveable portions. The absence of moving components may increase gadget dependability by lowering the risk of mechanical failure. [24]

6. Accuracy of dose

The microchip device includes numerous reservoirs, each of which may be precisely loaded with a little quantity of medication by microinjection or ink-jet printing. It's important that the amount of drug given to a patient matches the amount prescribed, especially when it comes to very powerful medications compounds. Because active devices can only be released when an electric potential is supplied to an anode, the amount of drug administered from a microchip filled using this printing process may be precisely regulated, and accidental overdose can be prevented. Larger dosages can be supplied by simultaneously opening numerous reservoirs. [25]

7. Improve shelf-life

A number of protein-based medicines have a short shelf life or are unstable. Water penetration into these protein medication formulations is one of the most prevalent reasons in this scenario. Water will not be able to diffuse into the packed reservoirs of a microchip because of the membrane layers. Thus, a protein drug's stability can be enhanced by first separating it from the outside environment (hermetically sealing it) and then storing it in its most stable state (solid, liquid or gel). [26]

8. Potential for local delivery

To enable local chemical delivery, the microchip device can be made tiny. The major benefit of local medication administration is that it may produce high drug concentrations at the application site while keeping systemic amounts low [27].

9. Complex release patterns

The microchip may be used to provide a simultaneous continuous and pulsatile discharge (Complex release patterns). Any complex chemical or drug release pattern may be reduced down into two components: release time and release rate. The control of both of these variables is what sets apart a controlled release microchip [28].

10. Compounds to be released

The reservoir unit of the microchip may hold a variety of substances that can later be discharged as necessary. Any chemical or chemical mixture may be used to fill each reservoir. Chemicals can be employed to fill the reservoir in the forms of solid, liquid, or gel. Pumps are the only microfluidic devices that can distribute liquid [29].

FUTURE APPLICATIONS:

The widespread application of microchip technology has the potential to completely transform the current healthcare system. The quality of life for patient populations will increase, therapeutic methods will change, and unnecessary spending will amount to savings of billions of dollars. While research on human microchips has only been utilized to treat a few specific illnesses, advancements will enable this technology to be used for a wider range of therapeutic purposes. Passively administered medications may have dose distribution mechanisms that, under other circumstances, would be difficult or unpleasant. It is possible to develop automated medication regimens that are safer and more successful for conditions like diabetes and hypertension that require dosage titrations [30].When combined with implants, this controlled-release method lowers the possibility of rejection and responses to foreign bodies, as well as inflammation and pain, enabling the body to recover from surgery more rapidly. Applications for microchips might be broadened to create synthetic glands. It may be possible to control current disease states and stop the onset of future hormone-related illnesses by controlling hormone regulation in the body that is connected to malfunctioning glands.Microchip delivery systems will be useful for diseases or treatments that frequently have a low compliance rate (such as mental disorders, some cancer medicines, long-term antibiotics, etc.) or the potential for abuse. The management of drug addiction may be improved for patients taking schedule II and schedule III medicines [31]. Patients who were dependent on their medication before implantation might be weaned off it until they saw the desired benefits. Due to improvements in microchip technology and clinical trials showing pulsatile release, steady medication pharmacokinetics, and utility and efficacy in treating illness conditions, the usage of microchips is increasing. The clinical situations in which a medicine (or a health condition) needs local release, pulsatile control, and/or decreased compliance burden require more investigation. Further investigation into the impact of breakdown byproducts on medicine release, compatibility, and toxicity is required since the anode membrane is electro thermally ablated.Diabetes is the main cause of death for 69,071 Americans per year, making it one of the top 10 killers in the US. Despite being in its infancy, microchip technology will have a tremendous impact on the way diabetes is treated, possibly saving the lives of hundreds of thousands of diabetics [32].The delivery methods of today's diabetes treatments are mostly constrained. Oral medications are poorly absorbed and have a long-lasting impact. Patients are occasionally turned off by the need for self-injection, despite the fact that liquid insulin (in the form of pumps or syringes) has a high bioavailability and quick absorption into the systemic circulation. Both kinds of insulin therapy also have a high proportion of treatment mistakes, including people giving themselves the incorrect dosage or forgetting to check their blood pressure [33].

CONCLUSIONS

Microchip-based implanted drug delivery systems provide localized delivery by directly implanting the device at the treatment site as well as on-demand delivery (pulsatile, adjustable continuous dose, and emergency administration, preset dosing cycle). The drug delivery microchip is designed in such a manner that it enables the safe, controlled release, and storage of several medications. Compared to the devices that aim to control the aforementioned, this one is both far simpler to operate and much more dependable.

The frequency of drug release (electromechanical or systems made of polymers). Since the microchip is self-contained and can be created using conventional microfabrication techniques, no interaction between the patient and the doctor is necessary. The proposed gadget has a lifespan of more than a year (assuming one dosage per day), although delivery capabilities depend on patient desire. In order to sense, excite, distribute to, and record from biological systems, internal drug delivery devices are being developed today leveraging the emerging disciplines of micro technology and nanotechnology. Some of these devices may be programmed, allowing for the advance or immediate storage and release of medications as needed. a silicon microchip that can regulate the dosing of one or more medications. When the anode membrane is damaged by electrochemical disintegration, drugs in solid, liquid, or gel form may be stored in small reservoirs and released in controlled patterns Internal medication delivery devices are now being created by utilizing the burgeoning fields of micro technology and nanotechnology in order to sense, excite, distribute to, and record from biological systems. Some of these devices could be programmable, making it possible to immediately store and release medications as needed or to do so in advance. a silicon microchip with the capacity to regulate the dosage of medication. When the anode membrane is damaged by electrochemical breakdown, drugs in the form of solids, liquids, or gels may be stored in small reservoirs and released in controlled patterns. These encouraging findings imply that new therapeutic peptides and proteins may be delivered via microchip-based implant technologies. Additionally, they show that stability-optimized solid-phase drug formulations may be packed and released in vivo and that drug administration from a number of unique reservoirs is not just possible with solution-phase drug formulations. Microchips have enormous promise in a variety of industries, including monitoring and control, microbiology, chemical detection, and medical diagnostics. In the near future, the "microchip" will be used to deliver several potent drugs.

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How to cite this article:

Das J, Rahman M, Rahman M. Microchip: a futuristic drug delivery system, *Curr Trends Pharm Res,* 2022; 9 (1): 179-194.