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Microneedles : A Smart Approach for Transdermal Drug Delivery System

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ABSTRACT

Due to the limitations of oral and parenteral medication delivery, which result in patient noncompliance, the Novel Drug Delivery System is currently more effective than the Conventional Drug Delivery System. The transdermal drug administration method is frequently used to deliver medications through the skin for both local and systemic effects. The stratum corneum's epidermal layer serves as a significant barrier for the transport of drugs via the skin. We can release a medicine by various techniques in a regulated manner with the aid of different sorts of microneedle patches on the skin, depending on the microneedle's design. Microneedles are made from a range of materials, including silicon, stainless steel, polymers, metals, and carbohydrates. These materials have been utilised to create coated, solid, dissolving, hollow, and hydrogel-forming microneedles. These microneedles transport different medications, proteins, vaccines, and immunobiological substances, and they are crucial in the treatment of many illnesses like cancer, diabetes, and pain management. The development of the microneedle faces numerous problems, including those related to stability, dosage accuracy, skin irritation cost, and more. The types, fabrication materials and processes, and applications of the microneedle drug delivery system are discussed in this review.

Keywords : Microneedles, Silicon, Solid Microneedle, Stratum Corneum, Hypodermic Needle.

I. INTRODUCTION

When the microneedle was first introduced in 1976, an American patent was simultaneously published that covered the use of the device for transdermal distribution. After that, with the brisk growth of the high precision microelectronics industry, microneedle manufacture and application have

advanced significantly [2]. Targeting the specific area of disease while minimising toxicity to healthy cells has improved the therapeutic efficacy of a medicine over time [6]. Needles hurt, Topical treatments' bioavailability is also decreased, and patients are indeed less likely to accept them [1]. The most popular ways to administer drugs are thought to be DD methods like oral intake or hypodermic injections. They do, however, have some drawbacks, such as discomfort [7]. Skin serves as the primary impediment to topical drug administration. The three basic layers of skin are the dermis, which is the thickest layer, the middle epidermis, and the stratum corneum, which is the uppermost layer. The stratum corneum layer, which serves as a main barrier, can only be penetrated by select substances, such as lipophilic and low molecular weight medications. [1]. Avoiding the dermal layer's nerve fibres and blood vessels, which are mostly found there. Therefore, the promise of painless delivery of both small and big molecular weight API is the main benefit of employing MNs [4]. The layer's relatively low permeability causes numerous issues when creating topical formulations. When drugs are administered via a microneedle device, more drug molecules can penetrate the skin because the drug molecules can cross through the stratum corneum layer. This technology stands out for its quicker action times, greater solubility, efficacy, self-administration, and patient acceptance. [1]. The use of microneedle patches on the skin results in the creation of tiny channels for the transportation of molecules, including cells and biomedical antigens. Microneedles have been the subject of numerous research for uses including collecting interstitial fluid (ISF) and blood, as well as administering low and high molecular weight biotherapeutics, medications, and vaccinations via the skin [3]. Years of study and development led to the creation of two methods: chemical, utilising penetration enhancers, and physical, utilising a variety of methods, including electrophoresis, sonophoresis, tape stripping, laser light-induced SC ablation, and more recently, the use of microneedles [5].

II. SKIN ANATOMY

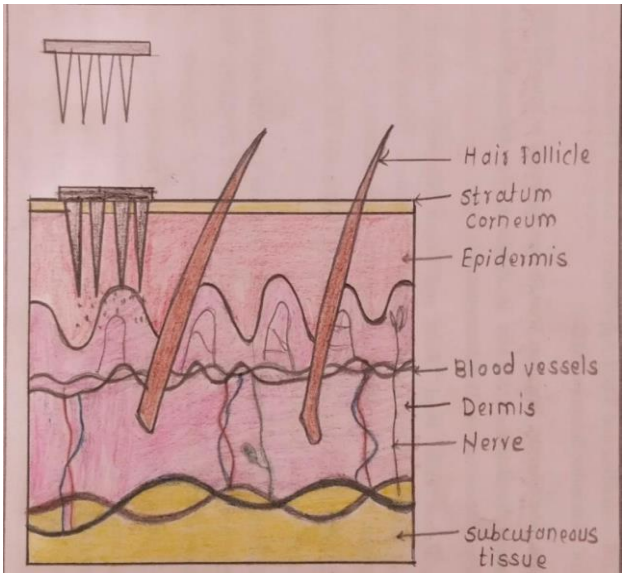


Figure 1: Anatomy of Skin

The human body's largest organ, the skin, serves a variety of purposes [14]. The skin is a multi-layered organ that serves as an essential barrier, shielding the organism from environmental hazards that are chemical, physical, and biological [15]. The three areas of the skin are as follows: 1) The uppermost cellular layer is called stratum corneum. 2) The dermis' middle layer 3) Hypodermis is the innermost layer. Healthy cells make form the 150–200 mm in thickness epidermal layer, but there is no vascular system. The stratum corneum, or dead cells that make up the epidermis' topmost layer (10–20 mm), serves as a rigid barrier. The interwoven fibro-elastic structure known as the dermis gives the skin its mechanical toughness. The difficulty in delivering drugs through the skin is getting through the healthy stratum corneum layer without damaging the nerve endings. To increase medication penetration through the skin, many chemical and physical methods have been used. Surfactants, fatty acids/esters, and fluids are examples of chemical processes that can degrade stratum corneum lipids or enhance the solubility of medications. Only a few medications can be

delivered through the skin using physical methods such electroporation, ionophoresis, magnetophoretic, and sonophoresis [8].

III. MODE OF ACTION OF MICRONEEDLE

A microneedle array is a group of numerous small needles, less than 1 mm in length, that are utilised to inject jabs and drugs into the skin. A microneedle patch is a microneedle array with an adhesive that can be placed onto the skin. The transient mechanical disturbance of the skin is the principle behind the medication delivery method, this enables the drug or vaccine to be placed into the dermal, and so it can quickly reach the target area. Additionally, microneedles provide tiny medication delivery channels without harming the nerve endings and blood arteries found in healthy dermis and epidermis. Consequently, medication distribution is more effective, and it is also easier to give pharmaceuticals with higher molecular weights and larger doses. Microneedle arrays are therefore regarded as minimally invasive technologies because they may pierce the skin without causing discomfort or drawing blood. The medicine or vaccination is contained within or coated with biomolecules before being inserted onto the skin using microneedles. Immediately after being inserted into the skin, these microneedles deliver the medication into the dermis. In order to achieve therapeutic response, the microneedle devices can circumvent the Stratum Corneum barrier and deliver the required dosage of medication to the dermis. comparing the locations where parenteral, microneedle, and topically administered semisolids transport drugs to the body [9].

IV. ADVANTAGES

- Delivery of large molecules is possible.
- Drug delivery that is targeted is conceivable.
- There is no long-term oedema or erythema, and tolerance is good [5].
- Effortless administration of the drug's active component.
- First-pass metabolism can be avoided, and an injection site heals more quickly than it would with a hypodermic needle.
- Convenience in administration.
- less microbiological penetration compared to before.
- Drug delivery can be aimed at a specific area of skin.
- A dose reduction may be necessary to maintain drug efficacy [8].

V. DISADVANTAGES

- As compared to hypodermic needles, dosage accuracy may be reduced.
- The medication must be given carefully to prevent irritating the skin's surface when moving.
- The veins may collapse if you provide injections often and repeatedly.
- Hollow microneedles may become blocked by squeezed cutaneous tissue [5].
- the external environment, such as skin moisture, may have an impact on delivery.
- When the patch is removed, the tip of the microneedle might separate and remain inside the skin
- A tiny dose of the medication (less than 1 mg) can be administered through bolus [8].

VI. TYPES OF MICRONEEDLES

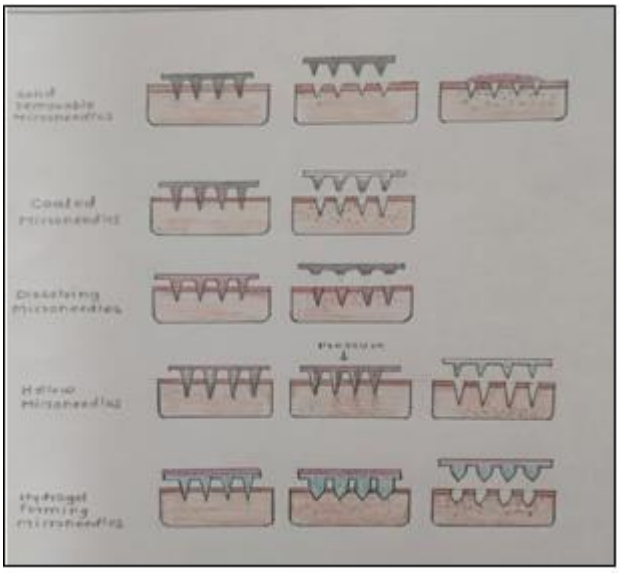


Figure 3: Types of Microneedles

A. Solid

To enhance drug delivery to the dermis, increase bioavailability, and enhance kinetic transport across the skin, this sort of microneedle design is created to pierce the stratum corneum. [6]. Solid MNs are non-medicinal MNs composed of silicon or metal that can be used for skin pre-treatment. Once the MNs have been removed and the damaged epidermis has produced microchannels, the medication preparation is administered to the puncture site and diffuses into the body through the channels. [10].

B. Coating

The medication is coated, sprayed, or applied on the MNs' surface the drug dissolves and is absorbed by the body when the needle is poked into the skin. This approach is mostly used with water-soluble medications, which have quick drug release, high user rates, and simple dose control [10]. The best procedures for producing coated MNs are dip coating and casting. Coated MNs are created using a variety of processes, including brushing, electrohydrodynamic atomization, inkjet printing, dip coating, spray coating, and gas-jet drying, depending on the physicochemical adsorption, chemical processing mechanism, and surface modification [12].

C. Dissolving

In order to generate dissolving microneedles, biodegradable polymers are combined with the drug. Microneedle insertion causes skin breakdown, which releases the medication [1]. However, the usage of these kinds of MNs to get beyond these restrictions is constrained by their high material costs or an unfavourable two-step administration technique. Recently, a water-soluble carbohydrate or biodegradable polymer have been used to create MNs [12]. This kind of MN necessitates full insertion, which is frequently challenging to carry out, and also experiences a delay in dissolution [6].

D. Hollow

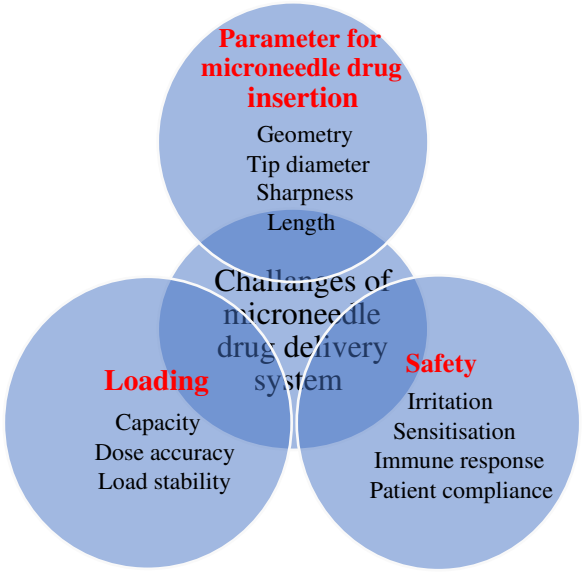
The empty space of the hollow microneedles is filled with the drug dispersion or solutions. There are holes at the tips. After being put into the skin, the medication is instantly deposited into the epidermis. The medicine is deposited in the dermis by hollow microneedles that are loaded with the medication solution. [1]. Comparatively speaking, hollow microneedles cannot be contained at low doses, which can result in subpar clinical outcomes [2]. Custom-built mechanisms can totally control how easily compounds housed inside the needle flow into the frame, creating a customised architecture for unique medication delivery needs [5]. Hollow MNs feature the most one-time infusion volume, the most precise dosing, and the most control over speed of all the Mn kinds. However, the manufacture of hollow MNs requires precision and is expensive. The drawback is that the needle wall's angle is improper, which can cause the medicine to leak out of the skin during injection, and the pinhole is easily covered by skin tissue. Additionally, the needle's physical strength is poor; it can easily shatter and stay in the skin [10].

E. Hydrogel-forming

This kind of microneedle is a relatively recent invention. Microneedles are made from polymers with super swelling properties. The hydrophllic nature of the polymers, which make up their three-

dimensional polymeric network, enables them to absorb a significant amount of water. When injected into skin, these polymers expand. Due to this, channels between the capillary circulation and the medication patch are created. [1]. Hydrogel-forming MN arrays constructed of cross-linked polymeric polymers are the most current advancement in MN technology. [12].

VII. CHALLENGES IN THE DEVELOPMENT OF MICRONEEDLES



Despite numerous suggested applications for microneedles, very few products have actually made it to the market. Safety and efficacy must be considered when making microneedles for the delivery of both small and large molecules. Metallic microneedles may result in irritation, erythema, swelling, discoloration, or other undesirable side effects because metal residues are left behind beneath the skin's surface. The usage of solid metallic microneedles runs the risk of causing skin irritation or leaving metallic residue in the skin. Additionally, they could produce biohazardous sharp waste after use, so careful destruction is important. Dissolving microneedles made of polysaccharides dissolve in the skin and are completely waste-free. The biggest difficulties in developing them are complete disintegration, proper insertion into the skin, and loading the medication mostly at the tip alone. Because hollow microneedles can dispense a wider variety of chemicals than other devices, they are another technique that is attracting the interest of researchers [8].

VIII. MICRONEEDLE FABRICATION MATERIAL AND THEIR CHARACTERISTICS

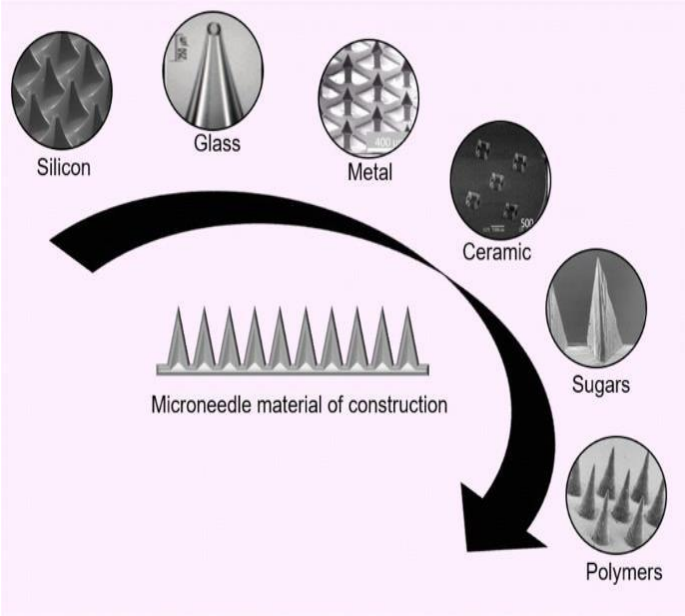


Figure 4 : Fabrication Material of Microneedles

A. Silicon

Silicon was used to create the first microneedle in the 1990s. Crystalline in shape and anisotropic in nature. The crystal lattice's orientation, which exhibits a variety of elastic moduli, affects its characteristics. Due to its flexibility, a variety of sizes and forms of needles can be produced. Its physical appeal is produced, and it can produce large quantities. The use of silicon in microneedles is constrained by its high cost and labor-intensive complex fabrication method. Furthermore, there are certain biocompatibility problems since silicon is fragile and some pieces may break and lodge in the skin, posing health risks [1].

B. *Metal*

Metals are used to make MNs because of their excellent mechanical and biocompatibility

characteristics. Metals have strong yield strength and fracture toughness ratings. Metals are more durable than silicon and are more difficult to shatter. Stainless steel was the first metal used in the manufacture of an MN, and titanium came next. Metal MN can puncture the skin, but it also runs the risk of triggering an allergic reaction when applied to the skin [6].

C. Ceramic

Due of (Al2O3resilience) to chemicals, it is mostly used. The highly energising covalent and ionic interactions between O and Al atoms lead it to form a stable oxide. Calcium sulphate dihydrate and calcium phosphate dihydrate are two more forms of ceramics that are utilised. Recently, an organically altered ceramic known as Ormoc® has been utilised. It is a three dimensional cross-linked copolymer. Different organic units can be used during polymerization to create a polymer with various characteristics. They are mostly made utilising the micro-moulding process. A micro-mould is used to cast ceramic slurry into. The use of micro-moulding techniques can be scaled up and is a less expensive approach [1].

D. Silica glass

Silica glass is a brittle, biologically inert substance. Type I glass has a lower elasticity than borosilicate glass, this is made of boron trioxide and silica. Glass MNs are now only utilised for practical purposes and are no longer employed commercially [5].

E. *Carbohydrate*

Microneedles constructed of carbohydrates can be produced rapidly and simply by casting hot melts of those components utilising silicon or metal microneedles as master molds. Prior to pouring the mixture into moulds, the drug to be given is added to the hot melts. When inserted into the skin, these microneedles can disintegrate, releasing their pharmacological payload [9]. The time-dependent degradation of carbohydrates regulates the transport of drugs into the skin. Although cheap and risk-free for human health, carbohydrates are difficult to produce because they break down at high temperatures. [1].

F. Polymer

Numerous polymers, such as poly (methyl methacrylate, or PMMA), poly (lactic acid, or PLA), poly (lactic-co-glycolic acid, or PLGA), poly (lactic acid, or PGA), poly (carbonate), cyclic olefin copolymer, poly (vinyl pyrrolidone, or PVP), poly (vinyl alcohol, or polystyrene, or PS), and poly (methyl vinyl ether, or These polymers are typically used to create microneedle arrays that dissolve or degrade and form hydrogels. These polymers can be used to create microneedles that are stronger than glass and ceramics but less strong than other materials [1].

IX. MICRONEEDLE MANUFACTURING METHOD

A.Laser Ablation method

Laser ablation removes material from a substrate by means of a focused optical light beam in order to create MN arrays. The production of MN arrays has been investigated using a variety of laser types. These include femtosecond laser equipment and CO2 UV excimer. The production of MNs is thought to be effective and quick using the laser ablation technique. Any metal can be shaped using a laser. The mechanical properties and MN structure of MN are altered by this method's heat effects at the cutting surface [6].

B..Lithography

The geometric shape master pattern is transferred to a substrate's surface using the lithography technique. Lithography is used as the first stage in the fabrication of an MN by other methods including microelectronics and micromachining. Glass, metal, ceramics, and plastics are just a few of the materials that can be produced using lithography. Additionally, it creates accurate geometries and slick vertical sidewalls [6].

C. Micro moulding

In the micro-moulding procedure, copies of master mould are created. A Polymer and drug active ingredient containing solution I used to cat the mould. For producing masters, micro moulding is regarded as a process. For manufacturing of MN, micromoudling is frequently employed with polymer material. With this method's limitations, it is challenging to regulate the depth of penetration, drug load capacity, and mechanical behaviour of the polymer. [6]

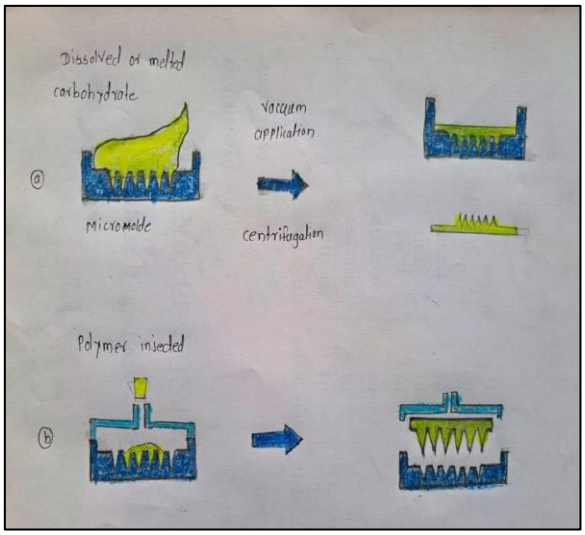


Figure 5: a) Micro-moulding b) Injection moulding

D.Injection Moulding

Another technique for fabricating MN is injection moulding. The biodegradable polymer poly is utilised to prepare microneedle arrays through the process of injection moulding (L-lactide co-glycoside). Medical devices including orthopaedic fixation devices and soft tissue fixation devices use polymer that the body can repair. To assess the microneedle array, researchers used energy dispersive x-ray spectroscopy, scanning electron microscopy, and skin penetration testing [16]. Due to usual screw size of 15 to 150 mm and the greater initial cost of equipment, the restriction on using injection moulding is controlling the small, short size [6].

X. APPLICATIONS OF MICRONEEDLE

A. Oligonucleotides delivery

Oligonucleotides are brief forms of either DNA or RNA. To get to their intracellular target, oligonucleotides are difficult to deliver. To distribute 20-mer phosphorothioated oligodeoxynucleotides, the microneedle technique was employed. It has been found that more medication gets to the site of action when skin has been damaged [1].

B. Vaccine therapy

A vaccine is a biological preparation. It gives a disease-specific active long-lasting immunity. Additionally, an effort was undertaken to create a microneedle patch that may be used to administer the influenza vaccination. In comparison to intramuscular injection, a smaller amount is needed when the medicine is delivered using hollow microneedles [1].

C. Immunobiologicals

Because they are painless, easy to use, and administer vaccine quickly, microneedles are superior to alternative delivery systems. Combination vaccination is one method of minimising the number of shots required; the well-known "DPT" vaccine, which protects against diphtheria, pertussis, and tetanus, is one such example. Numerous research has been conducted to determine the most effective method of administering vaccines using microneedles and adjuvants. Controlled and thorough penetration is a crucial factor to take into account while developing dissolving microneedles [8]. A typical MN type utilised for vaccine administration is one that dissolves. Dissolvable MNs were substituted for the hypodermic injection needles that are typically used to administer immunisations. Vaccinations against polio, Hepatitis B, Diphtheria, influenza, Malaria, and other diseases were given via dispersible MNs. Instead of using an injection, the anthrax protective antigen vaccination was administered to a rabbit using hollowed MNs. [6]. In the end, the researchers came to the conclusion that coated metallic microneedles or polymeric microneedles were both superior delivery methods for vaccinations [8].

D. Peptide delivery

When taken orally, peptides undergo enzymatic breakdown. The powerful peptide hormone

vasopressin has a synthetic equivalent called decompressing. It is used as an additive for low vasopressin levels. This medication is used to treat diabetes insipidus, haemophilia A, and young toddlers who urinate on the bed. This study found that microneedle distribution was both safer and more efficient than earlier approaches. [1].

E. Therapy of diabetes

Insulin, heparin, and human growth hormone should not be administered orally due to proteolysis breakdown and hindered absorption. Because the majority of widely viable biopharmaceuticals are administered via the parenteral route, a suitable non-invasive technique is preferred [8]. The discomfort of multiple daily injections, post-syringe disposal, and continuous glucose monitoring have reduced the effectiveness of subcutaneous insulin delivery. To get around these limitations, the nasal, pulmonary or inhaling, buccal, oral, rectal, ophthalmic, vaginal, intraperitoneal, and transdermal routes have been proposed for the delivery of insulin. [17]. Using microneedles, Verbaan et al. distributed macromolecules with various molecular weights throughout human dermatome skin. They discovered that micro needle arrays improved the transport of both low and high molecular weight drugs across the dermatome of human skin [8]. Peptides include the hormone insulin. It takes medicine to reduce the high blood sugar levels. Scientists have shown that administering insulin using a microneedle reduces the blood sugar levels more succes"full'. Ye and colleagues studied pancreatic beta-cell capsules that are combined with microneedles that sense blood glucose levels and produce insulin. A microneedle matrix containing synthetic glucose signal amplifiers (GSAs) was created as a result of this. These GSAs were made of nanovesicles that included the enzymes glucose oxidase, amylase, and glucoamylase. These amplifiers demonstrated the insulin releases from the cell capsules. For the delivery of various hormones, iontophoresis in conjunction with microneedles can also be investigated [1]. In order to enhance insulin permeability, stability, and bioavailability through several pathways, current MN technology has been created [17].

F.Lidocaine delivery

Local anaesthesia is accomplished with lidocaine. When compared to a hypodermic injection, microneedling lidocaine results in less pain, which improves patient compliance. Lidocaine was applied to the microneedle tips by Baek et al. When compared to the topical formulation in one trial, PEG-lidocaine coated microneedles released drugs most effectively within 3 minutes. [1].

G. Cancer therapy

Every year, millions of individuals throughout the world are affected by cancer, and cancer treatment is incredibly difficult. For the delivery of several anticancer medicines, microneedles have been studied. In order to cure melanoma, self-degradable microneedles were tested for their ability to administer anti-PD-1 (aPD1) over an extended period of time. Basal cell carcinoma is treated with a topical 5-fluorouracil cream. When applied to skin that had been pierced by solid microneedles, 5-fluorouracil's absorption was increased by up to 4.5 times. Bhavnagar et al. examined the use of microneedles to administer gemcitabine and tamoxifen for the chemotherapy of breast cancer. The negative effects of these medications could be decreased with localised distribution. Polymeric microneedles have also been studied for localised administration of anticancer medications and skin cancer [1].

H. Drug delivery

The first time a solid silicon MN was used to deliver medications was in 1998. Using a removable MN patch, human growth hormone was given transdermally to hairless rat skin. The weight of obese mice could be regulated by a soluble caffeine-loaded MN patch, which also served as an anti-obesity therapeutic strategy. MNs have also been employed for the transdermal permeation of a number of medications, including ibuprofen, ketoprofen, and paracetamol [6].

I. Disease Diagnosis

Micro needle technology, on the other hand, provides a painless and straightforward bioassays solution. A hollow MN can diagnose a number of illnesses, including diabetes, Alzheimer's disease, and cancer. Another use for MNs is monitoring patient health. For instance, the glucose level could be investigated using a hollow glass MN [6].

XI. EVALUATION PARAMETER

A. Characterization methods

A suspension or dispersion of the drug or an encapsulated form (solid lipid nanoparticles, nanoparticles, or nanoliposomes) that is contained can be applied to or injected into the microneedles. The polymeric solution can be used to coat or patch the medication. Depending on the type of formulation utilised in the microneedles, several physical and chemical parameters, such as particle size, polydispersity index, viscosity, and zeta potential, can be assessed for loaded pharmaceuticals. It is possible to assess the liposomes or nanocarriers' size, internal structure, and crystallinity utilising the dynamic light scattering, X-ray scattering, and electron microscopy transmission techniques.

B. Dimensional evaluation

A variety of methods are used to quantify the microneedle's tip radius, length, and height in order to analyse the needle geometry. The most popular techniques are electrical or optical microscopy. A 3D image analysis enhances knowledge of needle shape and assists with quality assurance. Using confocal laser microscopes and scanning electron microscopes, this has been performed (SEM).

C. *Mechanical properties*

In order to easily pierce the skin, a microneedle must be both sharper and strong enough to stay in place while inside the skin. The insertion force and the force where the microneedle loses structural stability are two crucial elements of a safe and effective microneedle design. “Safety factor” refers to the proportion in between two forces. [1].

D. Margin of safety

The margin of safety is defined as the difference between the force necessary to break microneedles and the force required to penetrate the stratum corneum. According to their hypothesis, if the ratio is smaller than one, a microneedle array can be utilised in a biological application. The margin of safety for silicon microneedles was examined using automated equipment. [8].

E. Penetration / Diffusion test

In-vitro and ex-vivo test

To investigate drug penetration or diffusion from a dose form to the application site, ex-vivo and in-vitro investigations are conducted on isolated animal or human dermatome skin. These tests can also be utilized to compare the degree of the molecules' penetration. In order to show the depth of Rhodamine B penetration in human dermatomed skin using confocal laser scanning microscopy (CLSM), Wu et al. employed 150 mm long microneedles. They claimed that below 80 mm of depth, the dye concentration was quite weak. Additionally, they tested the model drug's penetration through both microneedled and untreated skin using Franz diffusion cells, and they found that the use of microneedles increased penetration by 104 to 105 times [8].

In vivo test

Using only in-vitro studies, it is practically impossible to predict the skin permeability of formulations for a transdermal medicine delivery system. While conducting an in-vivo study, very different outcomes might be seen. In an in-vitro investigation, they observed that the transport of insulin through rat skin increased by 10–20 times, but in their in-vivo examination, microneedles were unable to administer the drug systemically. In-vivo tests should therefore always be conducted in addition to in-vitro/ex-vivo tests. Linkage between ex vivo and in vivo models

could lead to faster and more effective drug development. [8]

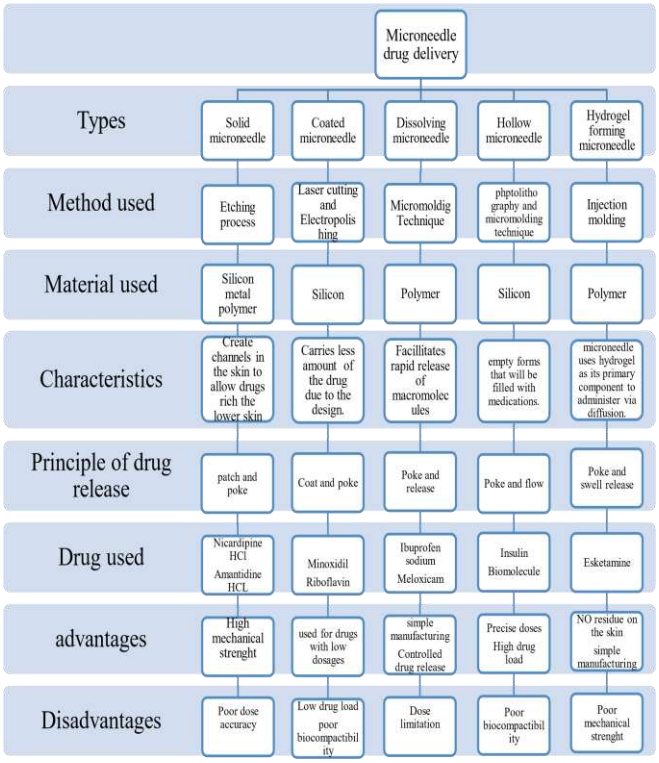
F. Biological safety test

Wu et al. determined the substances that might be extracted from micro-needles in accordance with the ISO 10993-12:2002 standard for "Sample Preparation and Reference Materials." To eliminate chemicals from microneedles, they were immersed in physiological saline at 37°C for 72 hours. To test for cutaneous irritation, the extract was then applied directly to healthy, shaven human skin. The test's negative outcome demonstrated the microneedles' biological safety [8].

XII. SAFETY

In order to transfer drugs through micropores, skin permeability must be increased. Microorganisms or viruses could enter the body and cause illnesses if the micropores are not healed after injections. Studies instead revealed a low probability of adverse effects from microneedles. There have been several examinations into whether or not microneedles could endanger skin safety. Vicente-Perez et al. gave hairless mice a twice-weekly injection of two microneedles for a time period of five weeks. Regardless of the microneedle composition, needle density, or number of treatments, there were no appreciable changes in the mice's skin's look or skin barrier function. At the conclusion of the trial, there were no significant differences between the experimental and control groups' serum indicators of stimulation/inflammation, infection, and immunity. Hyaluronic acid-dissolvable microneedle patches were inserted into the epidermis of explanted skin by Zvezdin et al. These tiny needles gently cut through the dermis layer. Four sites were discovered two hours after the skin was punctured with microneedles, leaving a total of 17 microneedle puncture sites. The periorbital area was treated with micro-needle patches in the trials, which varied in that they were left on for 25 minutes twice a week for three weeks [13]. Production of sterile MN devices helps to prevent any device-related toxicity and can ensure patient safety. However, caution should be used while selecting the sterilising method because some can irrevocably change the product's original characteristics and may increase manufacturing expenses. For instance, certain types of MNs may be weakened during terminal sterilisation utilising moist heat, microwave energy, or gamma radiation. McCrudden et al. investigated the efficacy and effects of various sterilising techniques on eroding and swelling MN devices. Wermeling et al. assembled the stainless-steel MNs into a patch under a laminar hood to guarantee sterility.

XIII. SUMMARY OF MICRONEEDLE



XIV. CONCLUSION

A dependable, effective, and cutting-edge method used in the field of biomedical applications is the microneedle. Since using hypodermic needles is painful, patients are less likely to accept them. Microneedling, however, is more dependable and efficiency in demonstrating patient compliance and

prospective outcomes. The many materials, kinds, and microneedle procedures are summarised in this article. To overcome all obstacles, the microneedle medication delivery method takes a lot of labour and research.

XV. REFERENCES

[1]. Tejashree Waghule, Gautam Singhavi, Sunil Kumar Dubey, Murali Manohar Pandey, Gaurav Gupta, Mahaveer Singh, Kamal Dua, Microneedle: A smart approach and increasing potential for transdermal drug delivery system.109 ed. Biomedicine & Pharmacotherapy;2019.

[2]. Jian Yang, Xinli Liu, Yujun Song. Recent advances of microneedle for biomedical applications: drug delivery and beyond. Volume 9. Acta Pharmaceutica Sinica B: 2019.

[3]. Zahra Faraji Rad, Philip D, Prewett and Graham Yujun Song, Yujun song. Recent advances of mi croneedle for biomedical applications: drug delivery and beyond. Volume 9. Acta Pharmaceutica Sinica B: 2019.J Davies, An overview of microneedle applications, materials, and fabrication methods. 12 ed. Beilstein j. Nanotechnol: 2021.

[4]. Ryan f. Donnelly, Thakur Raghu Raj Singh and A David Woolfson. Microneedle-based drug delivery systems: Microfabrication, drug delivery system, volume 17. Drug Delivery; 2010.

[5]. Shraddha Mahajan, Sonam Choudhary, Devshree Gayakwad, Dr. Sweta Koka, Dr. Pravin Sharma and Dr. N. Darwhekar, Review on Microneedle Drug Delivery System, Volume 10. World Journal of Pharmaceutical Research;2021.

[6]. Faisal Khaled Aldawood, Abhay Ander and Salil Desai, A Comprehensive Review of Microneedles: Types, Materials, Process, Characterization and Applications, Volume 13. MDPI; 2021.

[7]. Karmen Cheung & Diganta B. Das, Microneedles for drug delivery: trends and progress, Volume 23. Drug Delivery; 2014.

[8]. Shital H. Bariya, Mukesh C. Gohel, Tejal A. Mehta and Om Prakash Sharma, Microneedle: an emerging transdermal drug drug delivery system, Volume 64. Journal of Pharmacy and Pharmacology; 2011.

[9]. Rabinarayan Parthi and N. Divya Supriya, Review of Microneedle based Transdermal Drug Delivery Systems, Volume 12. International Journal of Pharmaceutical Sciences and Nanotechnology; 2019.

[10]. Wenjing Zhang, Wei Zhang, Cairong Li, Jianhua Zhang, Ling Qin and Yuxiao Lai, Recent Advances of Microneedles and Their Application in Disease Treatment, Volume 23. International Journal of Molecular Sciences; 2022.

[11]. Duarah, Manisha Sharma, Jingyuan Wen, Recent Advances in Microneedle-Based Drug Delivery: Special Emphasis on its Use in Paediatric Population, Volume 136; Europian Journal of Pharamaceutics and Biopharmaceutics; 2019.

[12]. Shailesh Duga, Rahul Tade, Rani Dhole and Sopan Nangare, Emerging era of microneedle array for pharmaceutical and biomedical applications: recent advances and toxicological perspectives, Future Journal of Pharmaceutical Sciences; 2021.

[13]. Jie Xu, Dalfeng Xu, Xuan Xuan and Huacheng He, Advances of Microneedles in Biomedical Applications. Volume 26. MDPI; 2021.

[14]. Pawar RG, Pawar SD, Gadhave MV, Jadhav SL, Gaikwad DD, MICRONEEDLES: NOVEL APPROACH TO TRANSDERMAL DRUG DELIVERY SYSTEM, Volume 2. Journal of Drug Delivery& Therapeutics;2012

[15]. Pooyan makvandi, Melissa kirkby, Aaron RJ. Hutton, Majid Shabani, Cynthia K. Y. Yiu, Zahra Baghbantaraghdari, Rezvan Jamaledin, macro carlotti, Barbara mazzolai, Virgilio mattoli, Ryan F. donnelly Engineering microneedle patches for improved penetration: Analysis, skin models and factor affecting needle insertion. Volume 13. Nano-Micro Letters; 2021.

[16]. Andrew Sachan, Roger J. Sachan, Junqi Lu, Hyiying Sun, Yingai J. Jin, Detlve Erdmann, Jennifer Y. Zhang, Roger. J Narayan, Injection molding for manufacturing of solid poly (Llactide-co-glycolide) microneedles, Volume 6. MRS Advances; 2021.

[17]. Fateme Nazary Abrbekoh, Leila Salimi, Sepideh Saghati, Hassan Amini, Sonia Fathi Karkan, Keyvan Moharamzadeh, Emel Sokullu and Reza Rahbarghazi, Application of microneedle patches for drug delivery; Doorstep to novel therapies, Volume 13. Journal of tissue engineering; 2022.

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