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A BRIEF OVERVIEW ON 3D PRINTING OF MEDICINES

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ABSTRACT

There are applications for printing in a variety of industries, including electronics, aviation, and medical. The pharmaceutical business might benefit greatly from 3D printing's highly customizable and individualized features. The potential applications of 3D printing in the pharmaceutical industry piqued our curiosity. We discovered that the following medical uses for 3D printing technology exist: Thirdly, it can precisely control the distribution of cells, extracellular matrix, and biomaterials to build organs or organ-on-a-chip for drug testing; secondly, it can print tablets with specific shape and structure to control the release rate; and thirdly, it can print pills on demand based on the patient's condition, making the dosage more appropriate for each patient's unique physical condition; Lastly, technology might be utilized to create transdermal microneedle patches to lessen patient pain or print loose porous pills to help with swallowing issues. The purpose of this study was to determine whether fused deposition modeling (FDM) and 3D printing might be used to create cinnarizine tablets. Cinnarizine, an antihistamine medication, was effectively loaded into commercial polyvinyl alcohol (PVA) and was used as a model drug for investigation. AutoCAD was used to create the tablet, and Cura Ultimaker 4.4 was used to cut the design. After printing the filaments into hollow, structural tablets with no infill, the medicine cinnarizine was added, and the upper surface was sealed using 3D printing.

KEYWORDS: Additive manufacturing, FDM, fast prototyping, tablets, oral dose forms, 3D printing.

INTRODUCTION

The pharmaceutical business has recently become interested in 3D printing applications because of its additional capabilities, which include complex drug release, complex drug product geometries, unique drug loading efficiency, and more. Many people think that the future of medicine will be more personalized, even going so far as to create medications for specific patients, like tablets.[2] Because of their low manufacturing costs, ease of administration, and patient compliance, tablets—by far the most widely used pharmaceutical dosage form—have been the subject of the most research. The standard technologies that are currently accessible.

Several unit activities, such as mixing, milling, granulation, drying, compression, etc., are necessary for tablet production procedures. 3D printing is more cost-effective and time-efficient than traditional methods since it can produce extremely complex and custom-designed objects. Nowadays, the most common 3D printing technologies utilized in the pharmaceutical preparation industry are binder extrusion printing, stereolithography appearance (SLA), and fused deposition modeling (FDM). Pill molds can be created via 3D printing, or medicine powders can be utilized as raw materials to print pills directly.[1]

HISTORY

Charles Hull, an engineer, first proposed additive manufacturing, another name for 3D printing, in the early 1980s. Layer by layer, materials are deposited to create an object in the manufacturing process known as 3D printing. In order to finish building a 3D item, it builds up the printed layers layer by layer using a pre-made 3D digital model. Because of its great flexibility, 3D printing enables local control over the microstructure and composition of materials.

Aprecia Pharmaceuticals is the well-known company. It is the first business to create a 3D-printed pill (Spritam) and to have the US Food and Drug Administration (FDA) approve the medication. Patients" with epilepsy can take Spritam to treat their seizures.(3) The business creates highly prescribed oral drugs that dissolve quickly using its in-house inkjet and powder bed 3D printing technology, called Zip Dose.

It Is the first platform for drug formulation that uses 3D printing to create pharmaceuticals. The Zip Dose technology allows for the disintegration of medications in a matter of seconds, allowing for far greater dosage loads up to 1,000 mg and more taste-masking possibilities.

Additionally, it helps people who have trouble swallowing medications. The British pharmaceutical giant Glaxo Smith kline (GSK) is another well-known example. In order to cure Parkinson's disease, GSK collaborated with researchers at the University of Nottingham in the United Kingdom to finish a study that produced 3D tablets using inkjet printing and UV curing.[4]

Using a printable substance, or ink, additive manufacturing (AM), also referred to as 3D printing, is a layer-by-layer fabrication technique that turns a digital image created with computer-aided design (CAD) into a three-dimensional object. In order to achieve compositional complexity, multi-material AM techniques allow for the precise placement of numerous different materials or combinations of materials. These techniques can be used to create multi-phasic 3D structures, where each phase represents a unique composition, as well as structures with compositional gradients. It should be noted that AM technique directly determines a material's printability and determines the type of Ink flaking, solution, melt, slurry, or powder that is used.[5]

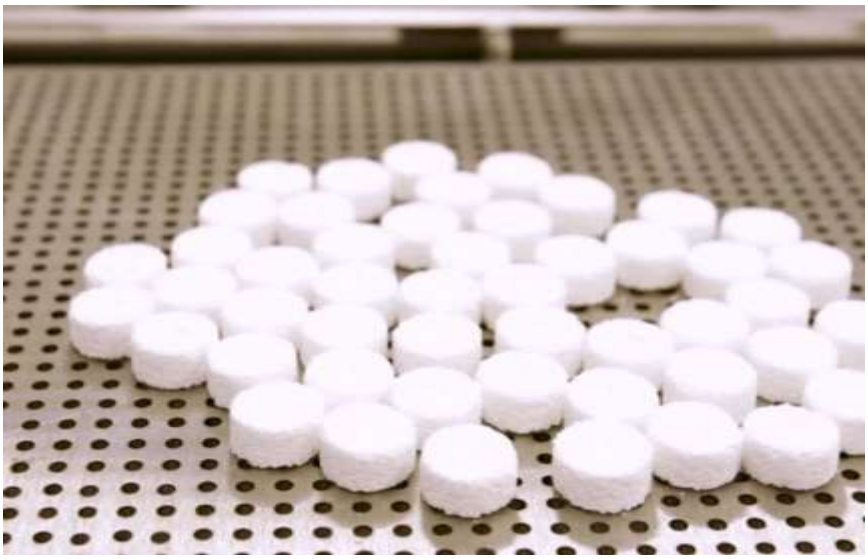

Fig. World first 3D Printing Tablet: Spritam.

Overall, by enabling specially made tablets that fit the target patient for personalized treatment, AM could provide a great deal of design freedom in the production of oral tablets. Tablets could be customized by adjusting the release profile and target dosage for individual APIs or combinations of APIs based on the patient's weight, age, and/or disease severity. AM may also be useful in early-stage drug development situations, such as assessing oral dosage forms for preclinical research (including dose flexibility), investigating custom designs

(shape, porosity, and composition), on-demand manufacturing (at the clinical site), and generally lowering resource consumption. Even with these possible benefits, there is a significant shortage of additively made oral tablets on the market following the US Food and Drug Administration's approval of Spritam®, the first 3D-printed tablet.[5]

Additive Manufacturing Technology

Extrusion-based, vat photo polymerization-based, droplet-based, and powder-based printing are the four primary categories into which the AM technologies utilized for oral tablet printing are divided in this research.[6]

Direct ink writing (DIW) and filament printing, also referred to by the trademark name fused deposition modeling (FDM), are examples of extrusion-based printing. Extrusion-based printing creates individual struts (or lines) that solidify onto the build substrate by extruding the ink, or printable material, via a nozzle in the form of a viscous melt, liquid, or slurry. The nozzle creates a 3D item layer by layer by following a specially created line path that is dictated by the g-code (computer-aided design). A thermoplastic solid filament serves as the ink for FDM. After being drawn into a heated nozzle, this filament is extruded as a melt. A viscous melt, liquid, or slurry (30–6 107 mPa.s) is the ink used for DIW. Low boiling point solvents, such dichloromethane (DCM) or tetrahydrofuran (THF), are recommended for using polymer solutions as ink because they permit the extruded ink to evaporate quickly and solidify into a polymer.[7]

Powdered based printing technology

Comprises selective laser sintering (SLS), which makes it possible to print powders made of metals, polymers, ceramics, and their composites. In order to sinter or fuse the powder particles spatially, a laser beam passes across the powder bath, increasing the temperature of the particles along the way. Following the formation of a single layer, the build platform descends and a new powder layer is placed from above.

The procedure is carried out again. The ink has good flow characteristics within the bed system and is a fine powder with a diameter of 10 to 100 µm. Typically, SLS machines need a lot of powder, which is not easily accessible.[8]

Droplet based printing technology

Incorporate binder jetting (BJ) and inkjet printing. A single droplet, 25–100 µm in diameter

(1–100 microliters), is ejected from the ink, which is a low viscosity solution (viscosity below 10 cP (mPa.s)). In order to create a solid line in inkjet printing, the droplet must be positioned on the print substrate and combine with the nearby droplets. The nozzle forms a 3D object layer by layer by following a specially created line route, much like in extrusion-based printing. In order to guarantee correct ejection from the nozzle and the shape of the droplet on the substrate, the ink should have a surface tension in the range of 28–350 mN m−1, as it is typically subjected to high shear rates (0.1–1 106 s−1). The liquid-to-solid change is essential to determining the printed structure's final shape, much like in the DIW process. The procedure is known as BJ when the ink is printed directly onto a powder bath surface. Keep in mind that BJ printing is also a type of powder-based printing. In BJ, the powder particles are held together by the binding solution known as ink. The ink droplets in this procedure create a coating by binding the granules together. The process is repeated as the powder platform descends and a new coating of powder is applied on top.

The ink used in vat photo polymerization-based printing is a photo curable viscous liquid (a prepolymer, macromere, or monomer), and photo curing is defined as light-induced crosslinking (photo crosslinking) and/or polymerization (photo polymerization).[9]

In traditional stereolithography (SLA) printing

The ink is spatially cured by a light beam (such as a laser or UV) passing over the vat. To form a layer, the beam adheres to a pattern that is specified by the g-code. The build stage descends into the tank once each layer is finished. Because modern SLA printers are inverted, the printed layer is pulled upward, greatly lowering the necessary vat depth and, thus, the amount of ink needed (around 2500 mL).Instead of employing a single light beam, a whole print layer is directly projected during direct light processing (DLP) printing, which causes a print layer to cure with each exposure. This may lower the resolution even though it greatly speeds up printing. Despite its high resolution (a single beam's size is about 25 microns), vat photo polymerization printing has restricted ink formulations and necessitates a lot of post processing, which is covered below.[10]

Materials for 3D Printing Oral Tablets

Polymers

a) Cellulose-Based Polymers
b) Poly (Vinyl Alcohol)
c) Eudragit

d) Polyvinylpyrrolidone
e) Polycaprolactone
f) Carbopol
g) Polyethylene Glycol
h) Polymer Blends/Mixtures

Additives

a) Plasticizers
b) Lubricants
c) Disintegrates
d) Binding Agents
e) Fillers

APIs

Common methods of 3d printing

Stereolithographic

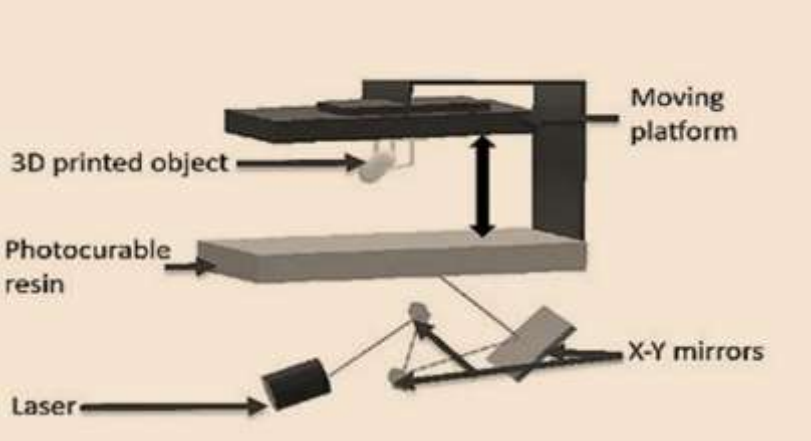

Fig: Stereolithographic printing.

Concept models, cosmetic-rapid prototypes, and sophisticated parts with intricate geometries can all be produced in as little as one day using the industrial 3D printing technique known as stereolithography (SL). A large range of materials can be used to create stereolithography parts, and SLA allows for incredibly high feature resolutions and high-quality surface finishes. Additionally, it provides other auxiliary services like painting, post-machining, and measuring and inspection to improve the final 3D-printed project design.

One kind of 3DP technology is stereolithography (SLA), which uses photopolymerization to solidify a liquid resin. In a vat of resin, a laser is directed to a precise depth, resulting in

localized polymerization (and consequent solidification). Layer by layer, solidification is continued until a solid, three-dimensional item is created. SLA has a higher resolution than other 3DP methods.[11]

Use

1. Accurate models and prototypes can be produced with stereolithography.
2. Stereolithography works well for producing precise three-dimensional (3D) models of a patient's anatomical areas, which are then used for pre-planning, implant design, and manufacturing, as well as for diagnosis.
3. Excellent for scale and concept models as well.
4. Stereolithography is used for part validation and prototyping to evaluate designs. This is because of its precision and capacity to create asymmetrical designs.[12]

Example: paracetamol tablet

Fig: Paracetamol tablet formed by stereolithography method.

As model medications, paracetamol (known as acetaminophen in the US) and 4-aminosalicylic acid (4-ASA), which is used to treat inflammatory bowel disorders, were chosen. A commercial Form 1+ SLA 3D printer (Form labs Inc., USA) was used to print the photopolymer solution after the medicines were introduced to the monomer solution.[13]

Due of its complexity in comparison to traditional tablet shapes and its difficulties in manufacturing using current production techniques, such as powder compaction, a torus design (donut shape) was chosen as the template for printing the tablets.[14]

The SLA printer was effectively used to create tablets with the medications, and multiple formulations with distinct qualities were created. Since the deterioration of 4-ASA utilizing FDM 3D printing has been documented before, It is particularly crucial that no medication was harmed throughout the 3D printing process. The ability to combine medications with the

photopolymer solution before printing and have them become trapped in the hardened matrices is a significant benefit of SLA printing. The fact that the printing is a one-step process that only requires the medicine to dissolve in the printing solution[15] is another benefit over FDM 3DP.

Drug release from the tablets begins in the gastric phase and continues during the intestinal phase for all formulations, according to the in vitro dissolution test conducted in a realistic dynamic dissolution simulation of the gastrointestinal tract. This depends on the formulations' composition. The authors claim that this technology provides a quick and easy way to create high-resolution drug-loaded tablets. SLA printing provides an alternate method for producing tablets containing thermosensitive medications since it lessens drug degradation as compared to FDM 3D printing.[16]

The production of medication-loaded tablets with certain extended-release characteristics may be made possible via SLA 3DP technology. This technology may eventually be used in manufacturing to create oral dosage forms, for industrial production, or even for customized dosages.[17]

FDM with drug loaded filament

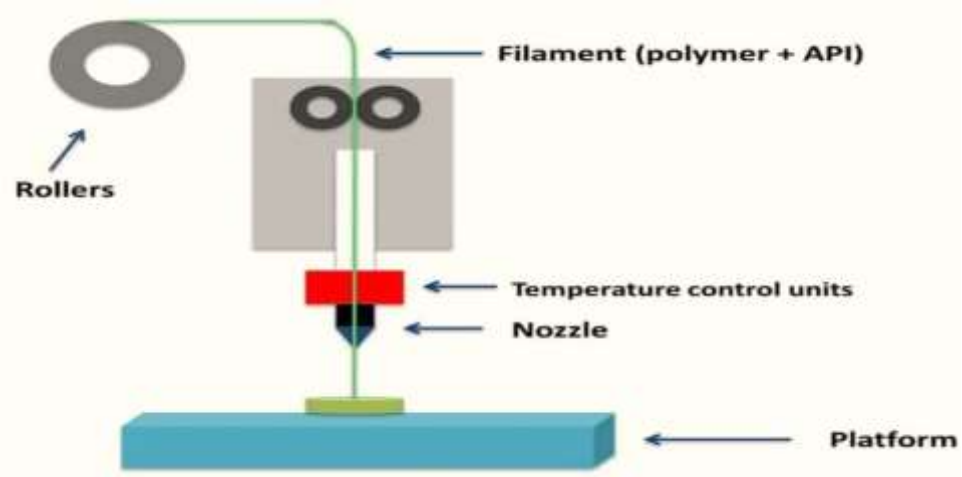

Fig: FDM with drug loaded filament.

A spool of thermoplastic filament is first loaded into the printer to begin the FDM production process. The filament is fed into the extrusion head and nozzle, where it melts, after the nozzle has attained the appropriate temperature. The three-axis system to which the extrusion head is attached enables it to move in the x, y, and z directions. Melted material is deposited layer by layer in pre-planned sites after being extruded in thin strands, where it cools and

solidifies. To speed up cooling, fans can be fastened to the extrusion head. It takes several passes to fill an area, much like when you colour in a rectangle with a marker. When a layer is complete, a new layer is deposited by moving the build platform downward (or, in certain machine configurations, the extrusion head upward). Until the portion is finished, this process is repeated.[18]

Rheology

In order to regulate FDM processing in terms of product flow continuity and consistency, the rheology of the composite material is essential. Because variations in temperature and time lead to irregular flow and the amount of material deposited during printing, the viscosity of the substance to be printed must be kept as constant as possible throughout processing.[19]

In order to provide easy extrusion via the nozzle head and prevent high pressure at the exit, which could harm the printer, the melt viscosity must also be low enough within the experimental temperature range. In addition to being necessary for efficiently extruding the composite material via the nozzle, high flow ability also enhances the adhesion between the printed layers upon cooling, reducing the number of interfaces.[20]

FDM Printer parameters

1. A number of process parameters can be changed in the majority of FDM systems. These consist of build speed, layer height, cooling fan speed, and nozzle and build platform temperatures. These modifications are rarely a designer's responsibility; they are typically established by an operator.
2. However, build size and layer height are problematic.
3. While industrial machines can measure up to 1,000 x 1,000 x 1,000 mm, consumer 3D printers typically measure 200 x 200 x 200 mm. If a desktop computer is desired (for instance, due to cost
4. Depending on the order location, the typical layer height employed in FDM ranges from 50 to 400 microns.

Functionality

Layer height will alter the part's smoothness by influencing its vertical resolution. Choosing a lower layer height is best if aesthetics are your first priority because it will produce a smoother finish. However, it is better to use a higher layer height when 3D printing a functional item because it will save time and money and increase mechanical performance.[22]

For instance, FDM items produced in PLA with a layer height of 300 μm are about 20% stronger than those printed at 100 μm.[23]

Selective laser sintering (SLS)

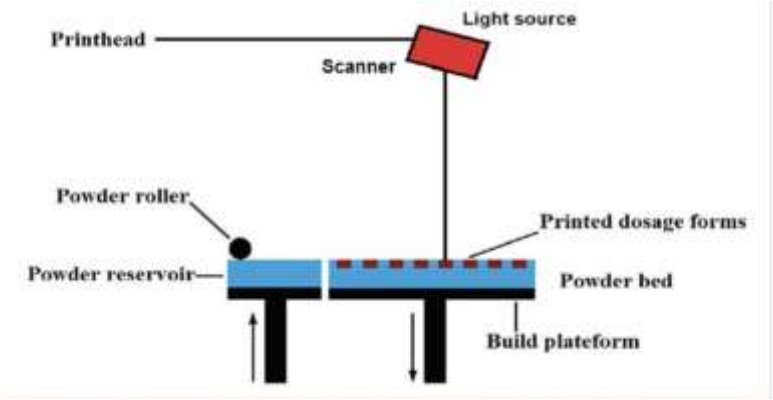

Fig: Selective laser sintering (SLS).

SLS has a lot of potential to increase compliance among vulnerable groups. The use of "Quality by Design" methods in research could make it easier to implement SLS in clinical settings, especially in situations where there are currently no Good Manufacturing Practices (GMPs) for 3D printing. However, powder recycling and medication stability continue to be particularly difficult in SLS. The pharmaceutical industry and compounding pharmacies could work together to solve these obstacles.[24]

Properties

There are two types of properties

- Intrinsic properties
- Extrinsic properties

Intrinsic properties

1. Laser Wavelength Absorbance
2. A laser beam serves as the thermal energy source; for the particles to sinter and form connections, they must absorb light with the same wavelength as the printer laser.
3. A stable state
4. Liquid phase sintering, which happens when the powder particles partially or completely melt, is the primary process of particle consolidation. Through capillarity action, the molten polymer diffuses throughout the powder, allowing for the creation of connections between neighboring powder particles.[25]

Extrinsic properties

Packing density, flowability, granulometry, and particle shape are important extrinsic factors for printability.

2. Fine particles are generally associated with high resolution but are not easily deposited on the building surface due to their poor fflowability.[26]

Variability in stuctures

The ability to create printlets with different geometries is a feature of 3D printing in general, not only the SLS process. SLS has the capacity to create extremely complex structures with excellent resolution, however accuracy varies among printers.[27]

Mechanical properties

Hardness generally tended to decrease as the heating temperature was lowered or the laser scanning speed was increased. Because porous printlets have weak interparticular bonding and shatter easily, mechanical strength is therefore strongly correlated with porosity.[28]

Application of SLS in personalized medicines

Drop on solid deposition

In DOS, a liquid binder is sprayed on the powdered material to solidify it in layers; the API can be distributed either in the liquid or solid phases. Specifically, the print glue method of discharging excipient eich binder onto API-loaded powder offers improved output since multiple inkjet heads can operate in parallel, higher API content, and less formulation complexity because similar binders are compatible with a wide variety of API powders.[29]

Binder jet

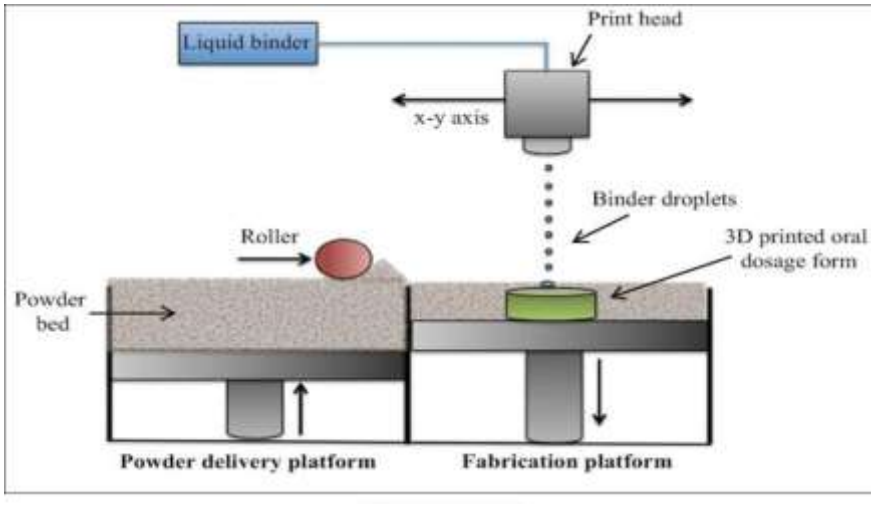

Fig: Binder jet.

The pharmaceutical industry's most successful three-dimensional printing (SDP) technique to date is probably binder jet printing. In order to produce Spritam, the first 3D printed tablet authorized by the Food and Drug Administration (FDA), the binder jet process was modified as an alternate mass manufacturing method in 2015. It is anticipated that during the next ten years, binder jet printing will continue to have a significant influence on formulation manufacturing. Specifically, hinder jet printing provides the advantage of creating oral dosage forms with distinct release properties, such as controlled-release platforms or fast-dissolving ones. This covers the background and methodology of hinder jet printing, its uses in medicine and pharmaceuticals, formulation development considerations, and the benefits and drawbacks of these procedures in the pharmaceutical industry.[30]

Preparation of orally disintegrating formulations

Orally disintegrating tablets (ODTs) have gained much greater attention in recent years due to their growing benefits. Typically, direct compression, wet granulation and compression, freeze-drying, hot melt extrusion, and other processes are used to create ODT dosage forms. Nevertheless, the tablets made using these techniques have insufficient porosity, which influences the rate of disintegration.[4] To make the preparation process more appropriate for small-dose medications, larger amounts of functional components should be used in order to produce quick disintegration and appropriate compressibility. The formulation has a larger porosity and a faster rate of disintegration because 3D printing technology prepares materials layer by layer rather than by compression. As a result, the printed items may exhibit superior mechanical qualities through prescription screening and CAD software design, suggesting the benefits of using 3D printing technology to prepare oral disintegrating tablets.[31]

Using CAD models as a guide, Yu et al. chose paracetamol as a model medication in 2009 and used DOP to create ODT devices with loose powder. The binder was dropped into specific places to create the inner regions. All of the pills broke down quickly in in vitro experiments; the average disintegration and wetting times were 23.4 and 67.6 seconds, respectively.[32] These findings demonstrated that a novel approach to the production of ODT drug delivery devices is provided by printing technology. Spritam, the printed tablet, showed quantitative release and broke down quickly in a matter of seconds. In addition to its quick dissolution, breakdown, melting, and splitting properties, the printed ODT dosage form can help patients with dysphagia.

Furthermore, the dosage form presents the potential for simple industrialization and production. Since then, 3D printed ODT dose forms have been the subject of several studies. DOP and traditional Chinese medicine were used by Lin et al. to create Suxiao Jiuxin oral disintegrating pills.[33] The findings shown that the 3D printed Chinese medication not only increases borneol's stability and addresses the issue of drug degradation in the conventional method, but it also successfully reduces the swallowing restriction brought on by taking too many single doses. Allahham et al. recently investigated the viability of using SLS 3D printing to create oral disintegrating printlets that contain ondansetron. Initially added to drug–cyclodextrin complexes, ondansetron was subsequently mixed with the filler mannitol. Compared to the commercial product, the in vitro dissolution of printed tablets showed rapid disintegration and released over 90% of the medication in 5 minutes.[34]

Controlled and released medicines

As patients' need for convenience increases the read desting frequency, there is an increasing demand for controlled release medications, sometimes known as D pharmaceuticals due to their propensity to change shape during digestion or function for extended periods of time. Patients who take many doses of a medication each day may find that extended release drugs improve patient compliance. They can take one pill in the morning rather than every few hours, or they may even take one pill for a week or more. Since children's body masses vary, it can be challenging to administer the right dosage to young patients, making pediatric care a crucial application area for extended release medications..[35]

For instance, Aprecia Pharmaceuticals reformulated the anti-epilepnic drug levetiracetam using 3D printing. The very porous structure of the new substance Spritam is not possible with conventional manufacture. When this structure comes into touch with saliva, the pill dissolves in a matter of seconds, which helps individuals of all ages who suffer from dysphagia, a condition in which they have difficulty swallowing medications.[36]

Zipdose, a unique powder best and inkjer 3D-printing technique, was used to make this ground-breaking advancement. The medicine itself is first placed down in a powdered coating during manufacture. A binding liquid is then printed at certain spots along the powdered sheet after the initial layer passes beneath an inkjet printer. Depending on the tablet's size, sacramive layers can then be printed up to 40 times. The medicine can be packed more tightly by printing the layers. It is possible to stack a single tablet that typically contains 200 mg to hold 1000 mg. The remainder is a high-dose medication that epileptic patients can

easily ingest and that gradually delivers a consistent dosage by breaking down within the body.[37]

The fastest formulation testing Is the suggested use for controlled-release dragis. Compared to large-scale traditional manufacturing, 3D printing the solit dosage forms allows for considerably faster study of the performance of various excipients in terms of the tablets and dissolution qualities.

Electronic pills are also on the horizon, even though controlled release 3D-printed capsules are more likely to have an impact on the pharmaceutical industry's future. Recently, researchers created a 30 produced, ingestible electronic pill capsule that can be linked to a user's smartphone and operated over Bluetooth. The capsule can be made to sense ambient variables, dispense medications, or both.[38]

Short run medicines

The stomach for a minimum of one month. Drugs tailored to individual patients benefit greatly from the shactrus features of 3D fabrication. The need for patient-specific care is growing as medications become increasingly customized.

The number of salutations rises. A white paper published by PTM, The Association for Packaging and Processing Technologies, claims that a renewed focus on customized care is transforming the pharmaceutical sector. It also notes that blockbuster fengs are becoming less common in the industry.

30 printing also has great potential for orphan pharmaceuticals, which are intended to cure illnesses that are occasionally created by the pharmaceutical industry for financial reasons.[39]

Benefits vs drawbacks of 3D printing in the Pharmaceutical industry

Since the early 1980s, when 3D printing was first developed, it has been used to produce nearly everything, from building supplies to vehicle parts to food and snacks. The pharmaceutical industry is one prominent area where 3D printing technology is being used. Medical professionals and pharmacists can also benefit from the technology. The pharmaceutical business is currently seeing an increase in demand for 3D printing. But these days, there is also debate about the misuse and application of 3D printed medications. This is because there may be some drawbacks to it as well. The advantages of 3D printing in the pharmaceutical sector will be covered in this blog post.[40]

Benefits of 3D printing in the pharmaceutical field

The pharmaceutical industry has seen advancements because to 3D printing. The few advantages that 3D printing offers are listed below.[41]

Quicker pre-medical assessment of new drugs

Pharmacists and medical engineers can now create customized medications by altering the design directly in the CAD file thanks to 3D printing. Iterations can be made more rapidly in this method. Additionally, these versions are far less expensive than the conventional method of producing medications.

For example, it is simple to make changes to the medications' excipients, salt forms, and dosages.[42]

Chance for personalized medication

A 3D printed pill, called a "polypill," can be utilized for patients who have several illnesses. Polypill is a single pill that combines several active substances. Numerous illnesses are treated with this. Additionally, certain medications are made to treat a specific patient's illness. But it's also important to take the patient's age, weight, and organ function into account.[43]

New formulations for improved drug

Certain pills are hard to swallow when made using the traditional approach. However, 3D printing allows for the customization of pills to a patient's specifications. For instance, medical engineers can design a medication that dissolves quickly in the mouth of the patient, making it simpler to swallow.[44]

On-demand pharmaceutical manufacturing

Instead of mass producing medications, 3D printing enables pharmacies and healthcare practitioners to produce them as needed. The pharmaceutical industry may transform the supply chain in this way. Consequently, reducing the cost of distribution.[45]

Drawbacks of 3D printing in the pharmaceutical field

While there are certain advantages to 3D printing technology in the medical field, there are also some drawbacks. This list does not include all of the drawbacks. However, pharmacies and medical professionals should be aware of the following significant disadvantages of 3D printing.[46]

Product liability risk

Pharmaceutical businesses can authorize pharmacies and healthcare professionals to use their designs thanks to 3D printing. As a result, printing medications locally is now simple.

Pharmaceutical businesses, however, are unable to monitor the effectiveness of each 3D printing procedure. Additionally, they must take into account the possible consequences of product responsibility.

Pharmaceutical corporations may have some of the blame for any unfavorable events or accusations of product defects, given their role in giving their product blueprint.

This fallout may also be the responsibility of other parties, including the product manufacturer, software developer, material supplier, and printer manufacturer.

Pharmaceutical businesses should create a procedure for validating their plans if they intend to use 3D printing. They will guarantee their legal and financial security in this way.[47]

Cyber risk

One of the biggest issues with 3D printing is the quick rise in the production of counterfeit medications. Additionally, hackers are already using 3D printers to create fake medications more quickly than they could using conventional manufacturing techniques. For example, hackers can mass-produce a medication abroad if they manage to obtain the drug's blueprint. The pharmaceutical company's intellectual property may be used in this way. Moreover, patients may suffer if the medication is manufactured incorrectly. Consequently, the pharmaceutical company's financial standing and reputation suffered. In addition, hackers have the ability to alter the medication's dosages or contents. Patients may suffer grave health repercussions as a result of this.[48]

Safety and efficiency of 3D printers

Authorized organizations like the FDA closely monitor the conventional method of mass-producing medications. This ensures that the items are made with care for both the corporation and the customers.

The FDA, however, is unable to control every printing process when it comes to 3D printing. Therefore, it may be questioned how the product is developed. Additionally, 3D printing still carries the risk of unneeded printing failures and malfunctioning 3D printers.[49]

CONCLUSION

One of the most cutting-edge medical technologies is 3D printing. It could lead to new opportunities in product distribution, manufacturing, and development. Aside from that, it makes it easier to offer personalized medicine.

The drawbacks of 3D printing in this sector must be taken into account in addition to the advantages already discussed. However, pharmaceutical businesses should prioritize knowing the aforementioned downsides if they are considering 3D printing in the future.

Do not be afraid to seek assistance from the professionals if 3D printing piques your interest. Sydney is home to a 3D printing company that offers exceptional 3D printing services.[50]

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