3D Printing in Pharma Industry

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Abstract: The pharmaceutical industry can benefit from and potentially use 3D printing technology. 3D printing is unique, advanced technique in medical field by enabling the decentralized and individualized manufacture of medications. The various 3D printing techniques are advantageous for producing conventional dosage forms since they are more versatile. Pharmaceuticals, aerospace, mechanical engineering, tool manufacturing, dentistry, and bio-printing are just a few of the industries that employ 3D printing extensively. According to Zip dosage technology, the commercially available formulation Spritam* was created using 3D printing. In surgical treatment, it is beneficial. The methodologies, applications, and certain difficulties in the field of additive manufacturing are summarized in this overview.

INTRODUCTION

The 3D printing has become one of the most revolutionary and powerful tool serving as a technology of precise manufacturing of individually developed dosage forms, tissue engineering and disease modeling. The current achievements include multifunctional drug delivery systems with accelerated release characteristic, adjustable and personalized dosage forms, implants and phantoms corresponding to specific patient anatomy as well as cell-based materials for regenerative medicine. [1] The key aspect of printing technology in the field of drug delivery is its versatility to create potential novel oral dosage forms. It also enables rapid, safe, and low-cost development in the production process which consequently leads to wide applications of this new technology in pharmaceutical fields.[2]3D printing technology can print an object layer by layer deposition of material directly from a computer aided design (CAD) mode.[3]Inkjet printing was the technique used to manufacture Spritam* tablets (levetiracetam) for oral use, the first 3D printed drug approved by the Food and Drug Administration (FDA) in 2016 by Aprecia Pharmaceuticals 3D printing involves wide technical range in pharmaceutical field with novel drug delivery system, generation of new excipients, improvements of drug compatibility. [4]

3D PRINTING TECHNOLOGIES

1. Stereolithography:

Stereolithography is the process of using a computer-controlled laser beam to turn liquid polymer or resin into a solid, thereby producing a three-dimensional structure. In comparison to earlier forms of 3DP, stereolithography has a number of benefits, chief among them being its astounding resolution and ability to avoid heat techniques that may be hazardous to particular drug molecules. [4]

2. ZIP DOSE:

The first and only commercial-scale, FDA-validated 3DP in new therapeutic areas for pharmaceutical companies is Zip dosage. It has a special zero-compression method and digitally coded layers that are utilized to create tablets with a high dosage and quick disintegration. So it aids in getting over a swallowing issue. Zip Dose Technology, created using Aprecia's unique 3DP manufacturing method, benefits both patients who require simple-to-take medications and cares, such as doctors and nurse practitioners, who desire simple-to-administer medications. [5]

3. Selective laser sintering:

SLS serves as a means of binding in the powder bed. During the printing process, the laser is intended to create a certain pattern on the powdery bed's surface, producing a 3D structure. One such Oro-dispersible pill made in this way is paracetamol. Currently, it is employed in the industrial production of ceramic, metal, and plastic. [4]

4. Inkjet printing:

A 3D printer uses an extruder head to heat and extrude the raw material filament on to platform or stage the

method .Inkjet printer implies use ink to print text graphics and image on various type of paper. [6]

5. Sintering lever:

The first solid freeform fabrication technology that was commercially available was stereo lithography (SLA), a laser-based printing process. A 3D object is created with SLA by carefully controlling the liquid resin's solidification using photo-polymerization (Chia and Wu 2015). In the photopolymer liquid-filled vessel is a mobile platform. After the appropriate laser is applied, the lifting platform is first lowered into a vessel to a depth corresponding to the thickness of the newly polymerized layer. The lifting platform initially starts near the liquid photopolymer's surface. Up until a solid 3D product is produced, this process is repeated. [7]

APPLICATION

1. Surgery for facial reconstruction benefits from 3D printing. Before the procedure, the implant is customized on a 3D surgical model to minimize tissue trauma and surgery time. [8]
2. Temporary crown restorations can be created with 3D printing more accurately than with traditional technique[9]
3. In the event of pulp canal calcification, 3D printing can be used to create specialized drills for root canal location for guided endodontic to root canal without perforation.[9]
4. It is simple and accurate to manufacture the intricate shapes required by the aerospace and aviation sectors. Manufacturing these via traditional methods is highly complex, and precision is also very low.
5. The printing method presents a huge chance for tracheobronchial disease restoration and support, which was challenging for conventional implants to be properly suited.
6. Medical experts have employed 3D printing technologies for a variety of purposes. Initially, 3D printers were solely used to create visual representations and working prototypes. However, as medical imaging or radiology technology such as computed tomography (CT) and magnetic resonance imaging (MRI) has developed, 3D printing technologies have improved in accuracy.[10]
7. Construction 3D printing makes it possible to construct complicated products more quickly and accurately while also cutting down on labor costs and material waste. Additionally, technology might make it possible to do construction in challenging or hazardous locations where labor is not appropriate, including inhospitable regions on Earth and in space.[11]
8. This technique makes the production of models quick.

Advantages:

1. Greater drug loading capacity than with traditional dose formulations, precise and accurate dosing of powerful medications that are given in small quantities for action. Decreased production costs because there was less material waste. [4]
2. Sustainability - Materials used in 3D printing are typically recyclable, and 3D printing has a lower environmental impact when producing a single product.
3. Creating drugs with precise quantities, or even 3D printed polyprintlets with variable amounts of many medications, can increase therapeutic effectiveness while lowering the risk of side effects brought on by incorrect dosing.[13]
4. The 3D models can incorporate a variety of materials. For a wide range of projects across numerous industries, it makes it incredibly simple to generate construction models or prototypes.
5. Products with superb surface finishes are made.
6. Less expensive travel is the main benefit. It might shorten the product's travel distance.
7. It is a more adaptable technique that makes the fabrication and creation of geometry possible, as well as partial design changes. These geometries incorporate a hollow chamber within a solid part to produce a unique new part.
8. Tangible design and product testing are mentioned under competitive advantages. Touching and experiencing a prototype cannot compare to seeing it on a screen.

Disadvantages:

1. The 3D printing technology is currently limited by size limitations. Very large objects are still not possible when built using 3D printers.

2. The cost of buying a 3D printer still does not make its purchase by the average householder possible. Different 3D printers are required in order to print different types of objects and the printers that can manufacture in color are costlier than those that print monochrome objects.[14]
3. .3D Printing Machines are expensive compared to the traditional manufacturing machines. It can cost you thousands of dollars or higher depending on machine size and functionality
4. In 3D printing of available materials are limited. Most materials are only made up of plastics which is not suitable for other applications that require high strength.
5. Potential risks and clinical implications are not well understood.
6. It is complex, skill based, and its requires lots of knowledge.
7. In some tenacious support material difficult to remove completely it may cause skin irritation

CHALLENGES

1. Several challenges such as versatile use, appropriate excipient selections, post treatment method to advance the enhancement of 3D printed products and to magnify the application scope in novel drug delivery system.
2. The possibility to print a lot of spare parts on demand can extend product guarantees and is actually much more environmentally friendly. Unfortunately, many companies rely on a business model based on low quality products and product rotation.
3. Safety of formulator, toxic vapoursgeneration.
4. Challenges include process optimization, excipient selection, limited selection of compatible materials, printer selection, pre- and post-processing costs, final product quality, product packaging, mechanical Instability, process validation, and print quality control. [15]
5. 3D is electronic process some error are occurs, more power consumption and due to lack of economics of skill.
6. Some technical issue in 3D printing.
7. Less supply of spare part.
8. Enable wide spread use of automated construction technology.
9. Absence of knowledge as well as absence of industrial particulate, so some difficulties in application of 3D printing.
10. A limitation of 3D printing in pharmaceutical manufacturing is that the method is difficult to scale compared to traditional manufacturing methods. Apart from the rapid production of pharmaceutical prototypes, 3D printing is mainly used for the production of personalized or uniquely characterized pharmaceuticals, where the manufacturing process takes place on a small scale. However, current 3D printing methods are slower processes than traditional manufacturing methods, making them unsuitable for large-scale drug manufacturing.

CONCLUSION

3D printing is boon to pharma industry. It improves applications in pharmaceutical research and biotechnology field and any other field. Also in generation of new excipient, improve drug compatibility. 3D printing is framework for investor, development of new drug, customized drug and it helps in business industry. In future 3D printing regulates and followed by pharmaceutical and other sector needed to safety and security concern.

3D printing is more flexible method. In social point of view; it increases gradually day by day influence of human's life, economy, and all technical as well as pharmaceutical sectors.

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