Review paper topics:- 3D Printing Technology In pharmaceutics.

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Abstract

3D printing is the process of creating objects layer by layer with the help of computers. This includes modelling, printing and finishing. There are many different printing methods and technologies used in 3D printing, including inkjet, fused deposition modelling and thermal inkjet. What are the benefits of 3D printing? Personalized medicine Small batch production Precise dosing of powerful drugs Prosthesis development Tissue engineering Drug development FDA Approved 3D-Printed Pill Zip Dose technology for fast disintegration.

Introduction

3D Printing is a manufacturing process in which the final product is created by adding layers of material such as plastic, metal, drug, cell culture, etc. with the help of a 3D printer. [(9)]. According to the GAO, 3D Printing can create a 3D structure from a digital model using the additive manufacturing process [(10)]. 3D printing has a variety of applications in different industries, such as healthcare, automobiles, aeronautics, food, chemicals and toys. In the healthcare sector, 3D Printing has been used for the production of various dosage forms of drugs, prosthetic devices, medical devices, artificial tissues, organs and many other products. [(11)]In recent years, several 3D printed products have been introduced into the healthcare and manufacturing market, including medical devices such as prosthetics, dental instruments, artificial organs (such as crowns, bridges, kidneys, hearts, etc.), artificial organs for research purposes, implants, and many more. Spritam®, the 1st 3D Printed Drug Approved by FDA, has stimulated a lot of research into the development of different medications using 3D Printing technology. [(12)]

Advantages of 3D Printing in Pharmaceutical [13] [14]:-

1. Accurate and precise dosing: 3D printing allows for the accurate and precise dosing of potent drugs, especially those administered at small doses.

2. Cost reduction: 3D printing reduces the cost of production due to lesser material wastage compared to traditional manufacturing methods.

3. Customization: Medication can be tailored to individual patients based on genetic variations, ethnic differences, age, gender, and environment, leading to personalized medicine.

4. High drug loading ability: 3D printed dosage forms have a high drug loading capacity compared to conventional dosage forms, allowing for more efficient drug delivery.

5. Complex drug-release profiles: 3D printing enables the production of dosage forms with complex drug-release profiles, which can be beneficial for multi-drug therapy with multiple dosing regimens.

6. Versatile applications: 3D printing technology has a wide range of applications in pharmaceutical research and fabrication, including the development of novel dosage forms and drug

Classification of 3D Printing

There are several methods and technologies used in 3D printing.

1. **Inkjet printing method:** This method involves spraying different mixtures of active ingredients and excipients in small droplets layer by layer onto a non-powder substrate.

2. **Fused deposition method:** In this method, polymers are melted and extruded through a heated nozzle to create the desired shape layer by layer.

3. **Direct inkjet writing method:** This method uses inkjet technology to dispense extemporaneous drug preparations onto 3D scaffolds.

4. **Zip dose method:** This method produces highly porous materials with modified doses, high disintegration, and dissolution levels.

5. **Thermal inkjet printing method:** This method uses a micro-resistor to heat a thin film of ink fluid, creating a vapour bubble that pushes the ink drop out of a nozzle.

6. **Binder deposition method:** This method involves using a binder to join layers of powder materials together.

7. **Material jetting method:** This method uses liquid polymers or waxy polymers to create objects layer by layer.

8. **Extrusion method:** This method uses thermoplastic polymer filaments that are melted and extruded to create the desired shape.

9. **Powder bed fusion method:** This method uses metal powders that are fused layer by layer using heat or laser.

10. **Photopolymerization method:** This method uses liquid photopolymers that solidify when exposed to light to create objects layer by layer.

11. **Pen-based 3DP method:** This method involves using a pen-like device to deposit materials layer by layer.

12. **Direct energy deposition method:** This method uses a focused energy source, such as a laser or electron beam, to melt and fuse materials.

13. **Sheet lamination method:** This method involves layering sheets of material and bonding them together to create objects. [22] [23] [24]

3DP Method	Traditional materials	Dosage forms
Binder Jetting	Polymer powders, sand, ceramic and metal powders	Tablet
Photopolymerization	Liquid photopolymers	Hydrogel
Powder Bed Fusion	Metal powders	Controlled release Implant
Material Jetting	Liquid (photo) polymers, waxy polymers	Tablet
Extrusion	Thermoplastic polymer filament	Nano capsule, capsule

TABLE:- 1 Summary of the different 3D Printing Dosage Forms with corresponding printing technology [25]

Personalized Dosage Form

Personalized dosage form: Personalized medicine is the practice of tailoring medical care to each patient's unique requirements, traits, and preferences [(1)]. This idea originated a long time ago when medical professionals saw similar symptoms in various illnesses that had distinct causes and could be treated in various ways. It flourished when diagnostic advances spread widely and the causes became clear [(2)]. 3D printing has made a significant contribution to medical devices and medicine.

BIO-INKS

Bio-inks are a type of bio-ink-like formulation that helps to bio-print a cellular product. Some of the most common bio-inks used are cell-loaded hydrogels, cell suspensions, and Decellularized Extra-Cellular Matrix-Based Solutions [(3)]. Bio-inks imitate the natural cellular microenvironment to facilitate normal cell processes like cell migration, cell division, and cell proliferation. [(4)]

Cancer

According to NCI, the term “cancer” is used to describe diseases with abnormal and uncontrolled cell division and, “tumours” that invade surrounding tissues and, “may or may not” spread to other parts of the body through systemic circulation and the lymphatic system” [(5)]. Since its introduction, there has been a great deal of progress in the field with a better understanding of pathophysiology and the causes of the disease. However, there are still obstacles to its treatment.

Applications in healthcare:-

Healthcare Dedicated dosage forms Drug fabrication, delivery Prosthetics Medical devices and models Tissue and organ fabrication Specialty surgical instruments Chemistry 3D Printing reaction-ware Ibuprofen Manufactured by Lee Cronin’s group High dose pills that dissolve and disintegrate quickly due to their porous nature Spritam® Levetiracetam manufactured and marketed by public health care.

Applications of 3D Printing in Pharmaceutical and Biomedical Studies:-

The applications of 3D printing in the pharmaceutical and biomedical fields are vast. It has been used for the production of viable tablets that meet regulatory tests and commercial standards. Furthermore, 3D printing technology has been utilized in tissue engineering, disease modelling, and the development of new drug dosage forms. It has the potential to reform the pharmaceutical manufacturing style and formulation techniques. [8]

Challenges and Optimization in 3D Printing:-

To ensure the quality of 3D printed products, various parameters need to be optimized, such as printing rate, printing passes, line velocity of the print head, and interval time between two printing layers. [16] [17] Post-processing steps, such as driving methods, also play a crucial role in the quality of the finished 3D-printed products. [18] [19] Increasing drug loading capacity and addressing complexities and clogging of spray nozzles are ongoing challenges in 3D printing technology.[20] [21]

Conclusion

3D printing has captured the imagination of many researchers and stimulated innovation in the healthcare sector. 3D printing has the potential to improve deliverable healthcare services by creating personalized products that are tailored to a specific patient. It can print

medicines in a variety of shapes, sizes, dosages and dosage forms with pre-defined characteristics such as drug release profile and functional dry matter (FDC).

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