Three-dimensional drugs: A new era in the pharmaceutical development

Since long, two dimensional printing technologies (flexographic printing and inkjet technology) are being applied in the pharmaceutical sector and inclusion of three dimensional (3D) printing technology in the same field is relatively new. 3D printing technologies are already in use in many areas like fashion, construction, aerospace and many other industries. In the field of medicine, it is being used in dentistry and tissue engineering. However use of 3D printing technology in pharmaceutical field, is quite recent.

What is Three-Dimensional Printed Drugs?

3DP is a form of “additive manufacturing,” wherein a structure is built by depositing or binding required materials in successive layers to produce a 3D object. The 3DP term is used as an umbrella term used as coverage of more than 20 printing technologies for healthcare and other industries. 3DP is also named as rapid prototyping, solid freeform fabrication or additive manufacturing.

This phase of advanced “additive manufacturing” techniques are under constant advancement for the past 30 years. The earliest technique “stereolithography” was developed by Charles Hull in the early 1980s. Many other techniques, for example, fused deposition modeling (FDM), selective laser sintering (use laser as power source), inkjet-based techniques, extrusion-based FDM and fused filament fabrication (FFF), and PAM-syringe technique, which are there for 3DP of pharmaceuticals.

Stereolithographic technique

It is one of the first 3DP technologies. In this technique, 3D structures are built by solidifying resins and curing it with ultraviolet rays. Photoinitiators help in converting light energy to chemical energy in the process.

Selective laser sintering

In SLS, powdered materials are sintered with the use of laser beam. With optimal control of heating, 3D structures are created, which needs to be stored in optimal storage conditions to maintain the geometry.

Fused deposition modeling

FDM technology was invented as early as the 1990s by Scott Crump. Basically, the FDM technology uses a thermoplastic filament, and two kinds of materials: modeling material and support material. The solid polymer filaments are heated to melting temperature (predefined in the computer file) by a heating block, which is deposited onto the build platform as per predefined coordinates (as defined in the computer-based design file, usually. STL file) through a print head. A layered structure can be formed by repeating this procedure. Another similar technology is FFF.

Another similar technique is PAM-syringe technique, which involves layer-by-layer deposition of semisolid or paste-like materials on a build plate through a nozzle.

Steps in Three-Dimensional Printing

The first step is design, which is followed by conversion of the design into a format which is readable by the printer,
processing of raw materials, printing, and removal and postprocessing or harvesting. The possible defect in the final product is banding and leaning, which are caused by a disturbance in printing in x-y coordinates, warping due to thermal disturbance, stringing, the collapse of the structure leading to loss of porosity, and unbound residuals.[1-3,5,6]

### Possible Advantages and Disadvantages

Use of 3DP has the advantage of adequate control on the spatial distribution of active pharmaceutical ingredients in the dosage form, which can help us to create more complex geometries and thus help us to formulate more complex designs with complex and individualized drug release profiles.[8,9] The geometric structure can be made as per requirement to alter the physical properties of the drugs like an increase in porosity, which may result in a subsequent increase in solubility and bioavailability.[2,3] In patients with swallowing difficulties (children, elderly, a stroke patient, Alzheimer’s disease, head-and-neck tumors, etc.), use of these porous tablets with high solubility can increase patient compliance.[7,8] 3DP has a role in the better personalization of sustained release formulations. This technology also has potential application in the fixed-dose combination field.[2,3]

Regarding possible disadvantages, there are several 3DP technologies based on the nozzle mechanism. Problems related to nozzle are a major challenge as stopping of the print head can occur, which can affect the structure of the final product. Clogging in the case of powder printing is another hurdle. Other points of concern are the possibility of altering the final structure due to mechanical stress and storage condition alterations, the effect of ink formulations, printer related parameters and effect of these on quality of printing, etc.[3,10]

To conclude, application of 3DP in pharmaceutical development of drugs has the potential to make drug manufacturers move closer to patients regarding personalization of therapy and flexibility of dosing and this can open up new and wonderful opportunity to pharmaceutical sector involved.

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### Conflicts of interest

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