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A Review Paper on Pharmaceutical Applications of 3D Printing Technology

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ABSTRACT: In a layer-bylayer process, three-dimensional printing (3DP) technology enables the manufacture of 3D objects with different geometrics. The customization of medicines with individually tailored doses, the ability to produce sophisticated and complex solid dosage types, on-demand production, and cost-effectiveness are some of the advantages of 3DP methods over traditional manufacturing processes. In addition, interest in the application of 3DP technology to the pharmaceutical manufacture of drug products and the production of different drug delivery systems has been growing in recent years. However, while 3DP technology has many potential medical and economic benefits, the broad applications of 3DP technology to pharmaceutical products are still limited by certain technological and regulatory challenges. In order to overcome the current limitations and promote patient-specific health care with on-demand personalized drugs in the future, continuous innovation and refinement in 3DP techniques are therefore required. This analysis presents some of the 3DP techniques appropriate for pharmaceutical production, as well as their applications for the development of drug dosage forms, suggesting the viability of this technology in standard commercial manufacturing.

KEYWORDS: Drug, Manufacturing, Materials, Technology, 3DP, Modern Printing, Pharmaceutical use.

INTRODUCTION

Three-dimensional printing (3DP) is a method of creating 3D objects from digital models by fusing or depositing materials in successive layers, which in a layer-by-layer process enables objects with different geometrics to be produced. The approach is also called additive manufacturing, rapid prototyping, or solid manufacturing of free-forms. Since the late 1980s, 3DP technology has been available and used in engineering and various non-medical manufacturing sectors, including the automotive, aerospace and consumer goods industries, but in recent years, rapid advances in 3DP methods and the emergence of versatile biocompatible materials have facilitated the pharmaceutical application of 3DP technology. In the early 2000s, following the first medical applications of 3DP for the manufacture of custom prostheses and dental implants, 3DP technology has since been used to directly print medical devices with highly complex 3D architectures and manufacture medical devices customized to fit the anatomy of a patient. By varying its energy source, material source, and other mechanical characters, different 3DP methods have been created. Printing-based inkjet (IJ) systems, nozzle-based deposition systems and laser-based writing systems, which can be further divided into several subtypes, depending on the materials and energy sources, are among the popular 3DP technologies applicable in pharmaceutical areas [1].

Because of its many inherent advantages over conventional technologies, including the customization and personalization of individually adjusted doses of medicines, the ability to

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manufacture complex solid dosage forms with high accuracy and precision, on-demand manufacturing, and cost-effectiveness, the application of 3DP techniques to the pharmaceutical manufacture of drug products gains a great deal of effectiveness. For instance, different drug delivery systems, such as oral controlled release systems, microchips, implants, pills, immediate release (IR) tablets, and multiphase release dosage types, have been developed using 3DP technology [2].

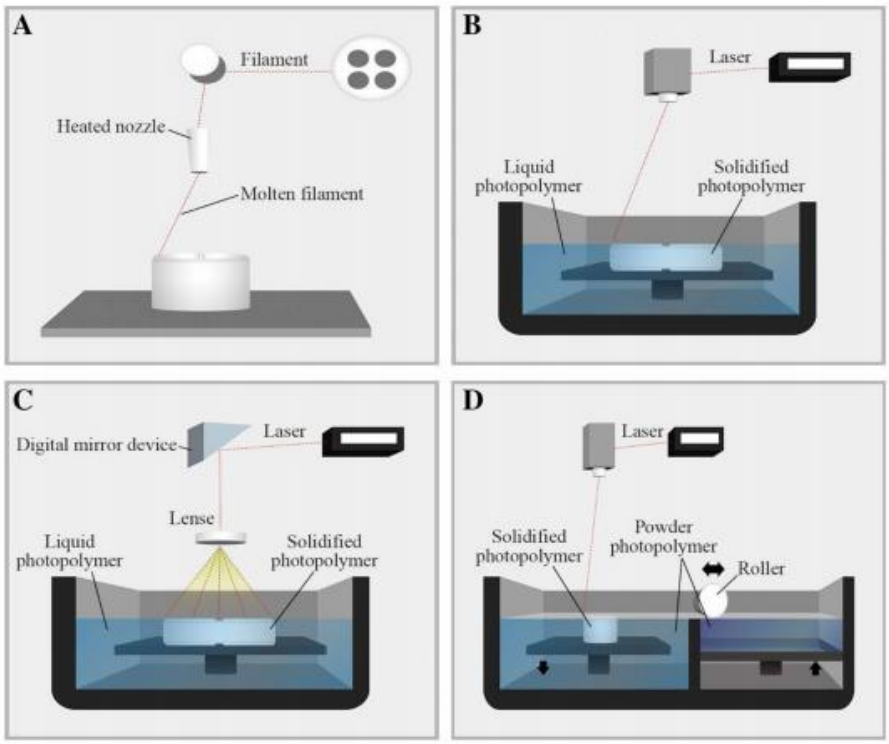

Figure 1: Illustrates the Graphical illustrations of 3DP processes. (A) FDM printer (B) SLA printer (C) DLP printer (D) SLS printer [3]

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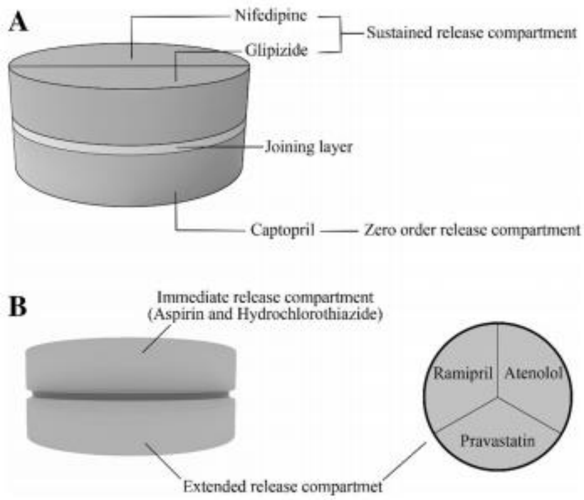
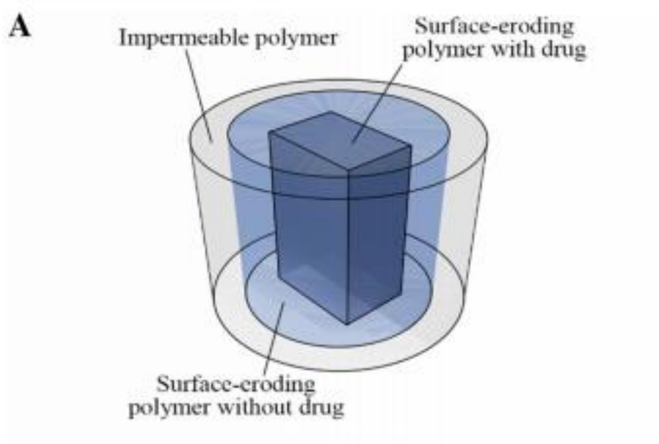


Figure 2: Illustrates the Polypill containing multiple active ingredients (APIs). (A) Polypill with three APIs, (B) Polypill with five APIs

DISCUSSION



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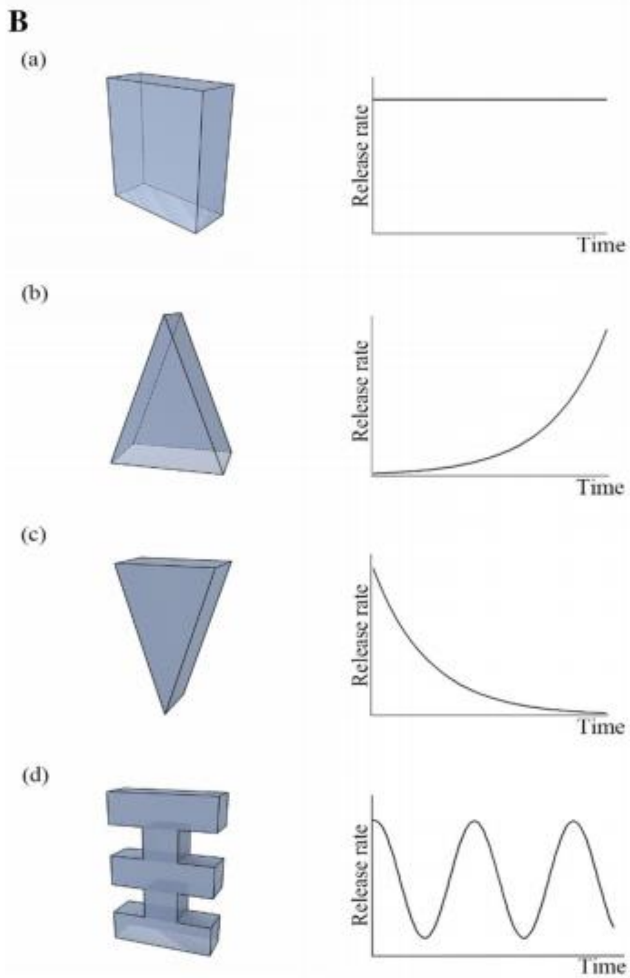

Figure 3: (A) "Scheme of the release-controlled tablet" (B) "drug release profiles" from each surface (a), increasing drug release (b), decreasing drug release (c), and multiple-pulse drug release (d) [4]

Various shapes of drug carrier models (or moulds) are manufactured to use 3DP to monitor more complex release profiles. Via complex models, it is possible to create tablets that contain multiple components, to produce a multi-action releasing profile. In this way, not only zero-or first-order APIs are released, but more complicated release profiles can be acquired. Sun and Soh (2015) have recently published a 3DP method for manufacturing customizable tablets that can achieve any desired release profile. The tablet consists of three elements, such as a drug surface eroding polymer, a drug-free surface eroding polymer, and an impermeable polymer forming a protective layer (Fig. 3). In particular, the surface-eroding polymer containing the drug is produced with a specific shape that makes the desired profile of drug release. The various drug release profiles are triggered by changing the shape of the surface-eroding polymer carrying the drug. Constant release, increasing release, decreasing release, and pulse release are obtained through the drug compartment nature of the surface eroding polymer [5]. Complicated drug release can be used with a drug that needs to be coordinated with the patient's biological cycles, such as pulse release.

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CONCLUSION

Via its working principles, various 3DP techniques have been developed and classified into subgroups. 3DP technology allows increasingly sophisticated and complex dosage forms of drugs to be produced and has increased the freedom to monitor the shape and microstructures of dosage forms. In addition, 3DP is a revolutionary and highly promising way of personalizing on-demand development and dosage type, which can increase patient compliance and medication efficacy, minimize side effects, address the stability problems of restricted shelf-life products, and ultimately contribute to patient-specific health care with personalized drugs on-demand. However, despite many potential medical and economic advantages, there are also some technical challenges limiting the wide range of applications of 3DP technology to the commercialization of products, including the limited choice of biocompatible materials available for 3DP printers, the pharmaco-technical problems of current 3DP methods affecting the stability of the starting materials, the capacity and the reproducibility of the materials. For the approval of pharmaceutical products manufactured using 3DP methods, regulatory modifications and considerations may also need to be identified.

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