Crimson Publishers
Wings to the Research

Short Communication

A Communication on FDM 3D Printing Polymeric Filaments with Applications in Biotechnology

ISSN: 2576-8840

Evando S Araújo*, Eumara M E da Silva and Pedro H N Cardoso

Department of Materials Science, Federal University of São Francisco Valley, Brazil

***Corresponding author:** Evando S Araújo, Research Group on Electrospinning and Nanotechnology Applications, Department of Materials Science, Federal University of São Francisco Valley, 48902-300, Juazeiro, Brazil

Submission: May 21, 2023
Published: May 25 2023

Volume 18 - Issue 5

How to cite this article: Evando S Araújo*, Eumara M E da Silva and Pedro H N Cardoso. A Communication on FDM 3D Printing Polymeric Filaments with Applications in Biotechnology. Res Dev Material Sci. 18(5). RDMS. 000948. 2023.
DOI: 10.31031/RDMS.2023.18.000948

Abstract

3D printing by Fused Deposition Modeling (FDM) is characterized as a technology to produce three-dimensional objects/models from the deposition of successive layers of the molten material of interest, on a work surface of a 3D printer. Most applications of the technique involve the use of conventional polymeric filaments for the production of parts with different geometries, which meet the specific demands of areas such as Engineering, Architecture and Education. In recent years, the manufacture and use of functional, biocompatible and/or biodegradable polymeric filaments containing active substances has been gaining prominence in the literature due to the possibility of producing prosthesis, artificial tissues and medicines with controlled release, at a relatively low cost, high precision and reproducibility. Here, we present a rapid communication about the possibilities of the FDM 3D printing using polymeric filaments, for applications in the field of biotechnology.

Introduction

Fused Deposition Modeling (FDM) 3D printing is characterized as a technology for the manufacture of three-dimensional objects, from successive depositions of layers of a fused material (usually polymeric-type, available in the form of cylindrical filaments) on a work surface of a 3D printer [1].

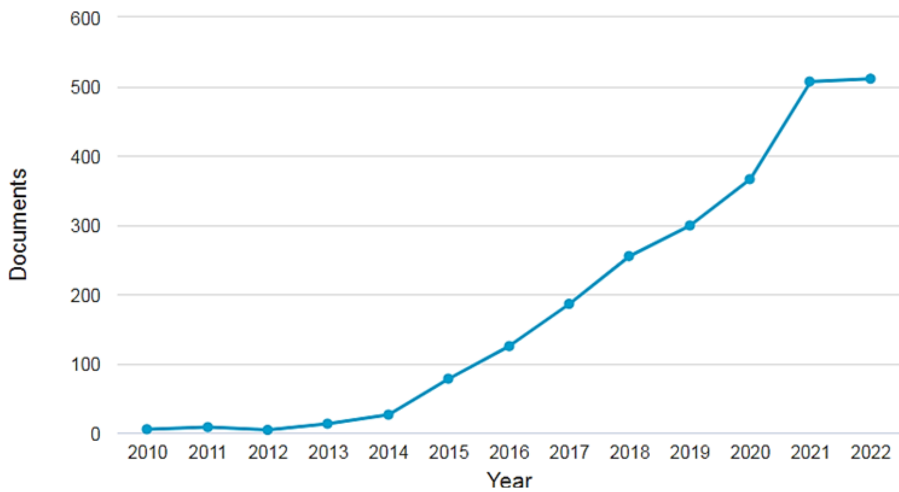

Figure 1: Number of scientific works published in the 2010-2022 period (2,383 document results), considering the keywords “3D printing” + “biomaterials” in the title, abstract or keywords of the document. Source: Scopus.com (2023).

Currently, most applications in FDM 3D printing involve the use of filaments produced with conventional thermoplastic polymeric material such as, for example, poly(lactic acid)

(PLA), poly(ethylene terephthalate) (PET) and poly(acrylonitrile-butadiene-styrene) (ABS), for the production of conventional objects with different geometries [2,3]. Unconventional filaments based on biocompatible and (or) biodegradable polymers have also been investigated for applications in emergency and related areas in materials science, such as in Biotechnology. As a reference, the global market for 3D printing for biological applications is forecast to grow at an annual rate of 21.5% until 2024, with an open field for research and industrial innovation in the sector [4]. Figure 1 shows an example of the growing interest of the scientific community in recent years for research involving 3D printing of biomaterials.

The FDM 3D printing has received attention in the field of biotechnology for the possibilities of manufacturing biomedical devices such as artificial tissues and organs, prosthesis, implants and customized anatomical models and production of solid solutions for controlled drug release, ensuring greater precision in the shape of parts, ease of production and user customization [5]. These new possibilities are directly influenced by advances in research aimed at developing bio polymeric filaments.

The process to produce filaments for these last applications is similar to that of conventional filaments, and differs from the former due to the preference for the use of biopolymers (formed by macromolecules, which provide biocompatibility, biodegradability and non-toxicity to organism cells). Poly(vinyl alcohol) (PVA), poly(vinyl pyrrolidone) (PVP), poly(ethylene glycol) (PEG) and poly(caprolactone) (PCL) (from synthetic origin), and collagen and chitosan (from natural origin), have been highlighted among the main biopolymers for the 3D printing filaments production, with biological applications [6].

Outstanding applications

Currently, the main applications of FDM 3D printing in Biotechnology involve the development of artificial prosthesis and tissues, and pharmaceutical solid solutions. The manufacture of prosthesis and artificial organs by 3D printing aims to treat pathologies resulting from accidents, and deformities resulting from genetic alterations [7-9]. The 3D parts can be used as a model for *in vitro* tests (replacing animal and human tests), as graft and/or biologically active materials, and in surgical planning, taking into account the anatomy and physiology of the organs. Three-dimensional models assist professionals to explore the different possibilities of interventions, gain experience with simulated surgical procedures and obtain superior results from the action of materials [4].

Another outstanding application is the production of customized pharmaceutical solid solutions of polymeric matrix to safely introduce a pharmaceutical substance into the body, for a specific therapeutic effect [10]. The first product approved for successful commercialization for this type of device, produced via 3D printing, was Spritam, which has been used in the treatment of epilepsy since 2015 [11].

The arrangement of drugs in selective polymeric matrices emerged with the strategic objective of proposing new kinetic profiles of drug action, increasing their bioavailability and/or their delivery to specific organism regions, to the detriment of other usual forms of administration. 3D printing has proven to be a technology with great capacity to create medicines in a precise, fast and simplified process, providing all the necessary characteristics for the controlled and personalized release of drugs to the patient [12].

Personalized treatments can help, for example, patients who need several daily administrations of medication to maintain a certain functional concentration of the active in the organism. The use of solid solutions with hydrophilic polymers or with solubility dependent on the pH of the medium, with a variety of geometries and concentrations, can change the release profile of a drug to reduce the number of daily drug administration [8,14]. Another possibility of using the technique is to produce customized medicines for instantaneous release at the specific site of action, in order to reduce its side effects [13-15].

Conclusion

A rapid communication about FDM 3D printing polymeric filaments with applications in biotechnology was presented. In summary, the mentioned applications of FDM 3D printing have fulfilled demands in Biotechnology with high precision and composition control and chemical reactions from the process. In addition, the technology has a relatively low cost to meet the requirements of biocompatibility and functionality, compared to other conventional techniques.

Acknowledgement

The authors would like to thank Fundação de Amparo a Ciência e Tecnologia do Estado de Pernambuco – FACEPE - Brazil (APQ 1387-3.03/22 and IBPG-0849-3.03/20 Projects) for financial support.

Conflict of Interest

The authors declare no conflict of interest.

References

1. Melocchi A, Uboldi M, Maroni A, Foppoli A, Palugan L, et al. (2020) 3D printing by fused deposition modeling of single- and multi-compartment hollow systems for oral delivery - A review. International Journal of Pharmaceutics 579: 119155.
2. Arefin AME, Khatri NR, Kulkarni N, Egan PF (2021) Polymer 3D printing review: materials, process, and design strategies for medical applications. Polymers 13(9): 1499.
3. Brambilla CRM, Okafor-Muo OL, Hassanin H, Elshaer A (2021) 3DP printing of oral solid formulations: A systematic review. Pharmaceutics 13(3): 358.
4. Higgins M, Leung S, Radacsi N (2022) 3D printing surgical phantoms and their role in the visualization of medical procedures. Annals of 3D Printed Medicine 6: 100057.
5. Tappa K, Jammalamadaka U (2018) Novel biomaterials used in medical 3d printing techniques. Journal of Functional Biomaterials 9(17): 1-16.
6. Baranwal J, Barse B, Fais A, Delogu GL, Kumar A (2022) Biopolymer: A sustainable material for food and medical applications. Polymers 14: 983.

7. Murray-Douglass A, Snoswell C, Winter C, Harris R (2022) Three-dimensional (3D) printing for post-traumatic orbital reconstruction, a systematic review and meta-analysis. British Journal of Oral and Maxillofacial Surgery 60(9): 1776-1183.
8. Paul GM, Rezaienia A, Wen P, Condoor S, Parkar N, et al. (2018) Medical applications for 3D printing: recent developments. Missouri Medicine 115(1): 75-81.
9. Yadav D, Sehrawat RA (2019) Review on 3D printing technology application in healthcare. International Journal of R&D in Engineering, Science and Management 8(6): 1-6.
10. Mancilla-De-La-Cruz J, Rodriguez-Salvador M (2022) Applications of 3D printing technologies in oral drug delivery. Materials Today: Proceedings 70(1): 477-482.
11. Bianchi M, Pegoretti A, Fredi G (2023) An overview of poly(vinyl alcohol) and poly(vinyl pyrrolidone) in pharmaceutical additive manufacturing. Journal of Vinyl and Additive Technology 29(1): 223-239.
12. Trenfield SJ, Januskaite P, Goyanes A, Wilsdon D, Rowland M, et al. (2022) Prediction of solid-state form of SLS 3D printed medicines using NIR and Raman spectroscopy. Pharmaceutics 14: 1-18.
13. Stewart SA, Domínguez-Robles J, Mcilorum VJ, Mancuso E, Lamprou DA, et al. (2020) Development of a biodegradable subcutaneous implant for prolonged drug delivery using 3D printing. Pharmaceutics 12: 1-16.
14. Haleem A, Javaid M, Vaishya R (2020) 3D printing applications for the treatment of cancer. Clinical Epidemiology and Global Health 8(4): 1072-1076.
15. Saroia J, Wang Y, Wei Q, Lei M, Li X, et al. (2019) A review on 3D printed matrix polymer composites: its potential and future challenges. The International Journal of Advanced Manufacturing Technology 106(1): 1695-1721.

