MATERIALS SCIENCE AND TECHNOLOGIES

Mechanical and Thermal Properties of Engineering Thermoplastics Composites

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Chapter 8

Revolutionizing Healthcare and Dentistry: The Transformative Impact of 3D Printing on Customized Solutions

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Abstract

This review article explores the use of 3D printing in the biomedical field. Although various 3D printing techniques exist, fused deposition modelling (FDM) is an exceptionally versatile choice for crafting biomedical prototypes and structures. The utilization of 3D printing offers many advantages in the biomedical field, particularly in dental implants. Notably, they can provide patient-specific designs and unique implant structures. To utilize the full potential of the FDM technique in any field, including biomedical industries, it is imperative to understand its mechanical properties. Factors such as the gap sizes between adjacent paths and filament orientations influence mechanical performance. For instance, smaller gaps can enhance the material density, whereas meticulous filament orientation optimization enhances structural integrity. This review article provides an overview of the role of 3D printing in biomedical applications, including mechanical properties and dental prototypes. A promising future for this technology is to improve patient care and outcomes.

Keywords: 3D priting, biomedical, mechanical properties, dental

1. Introduction

3D printing is the widely applied additive manufacturing (AM) technique for numerous fields such as materials engineering, mechanical engineering, computer science, electrical, electronics, biomedical engineering etc. The evolution of 3D printing started as early as the 1980s. 3D printing was marketed 3D-Systems for the first time in 1987 and is currently applied not only for fabricating prototypes but also for large-area manufacturing. The advantages of 3D printing are less material loss, ease of fabricating complex shapes and cost effective [1].

3D printing has matured as a driving force for the world's development in the technology for manufacturing, and hence they are implied widely in the sectors of space, automotive parts, bio-medicals prototypes, home accessories, stationeries, ornamental making, creative items etc. They are simply accessible, effective, efficient as they are not complex, cost-effective and quick. 3D printing involves the fabrication of products directly from their raw material using a 3D digital model, as the raw material gets added in a layer-by-layer sequence [2]. The FDM technique is the widely used manufacturing technique of all 3D printing techniques because of its non-laser application. It is cheaper in terms of usage and maintenance. Besides, the equipment set up for FDM is smaller, portable, and easy to use with a common operating interface. Also, the fabrication that requires multi-phase to get multi-functional compound materials can be achieved through multiple nozzles and multichannel. A magnificent achievement in the field 3D printers was made when the FDM-named additive manufacturing facility (AMF) was sent to space for the first time by the US National Aeronautics and Space Agency (NASA) in 2014 to print the spanner used for maintenance and repair in the orbit's space station [3, 4].

A wide range of materials was developed for 3D printing, including synthetic polymers, natural polymers, composites, metals, ceramic substances and wax material [5–8]. Polymer filaments with a low melting point are the consumable 3D printing materials, which mostly includes polylactic acid (PLA), acrylonitrile butadiene styrene (ABS), polycarbonate (PC), and polyamide (PA). Though materials like acrylonitrile butadiene styrene (ABS), thermoplastic polyurethane (TPU), nylon, and polyetheretherketone (PEEK) are the most preferred 3D printing materials, they are potentially hazardous too. This could be because of harmful volatile organic compounds and ultrafine aerosol that are found released during 3D printing processes. For example, the 3D-printed objects fabricated using these polymers are found to be toxic to zebrafish embryos, which are model organisms widely used for research in biological labs [9]. Therefore, it is essential to manufacture hazardous-free 3D printing materials that are less toxic.

Natural polymers have become important and replaced environmentally risky synthetic polymers as the most sought-after 3D printing material [10]. For example, PLA, one of the promising and widely used FDM 3D printing material technology, has gained the interest of researchers. Polylactic acid (PLA) is a natural polymer. PLA is renewable, eco-friendly, sustainable and most importantly biodegradable [11]. Contradictorily, the 3D printing materials are themselves obstacles to the development of 3D printing technology due to some practical issues encountered during 3D printing. These are entirely unavoidable. Some of the 3D printing materials get a volume change and are subject to residual stress due to their crystalline nature, which could lead to dimensional problems. These are common with natural polymers, whereas synthetic polymers like ABS and PC are free of dimensional problems. However, synthetic polymers could be subjected to higher shrinkage. Synthetic polymers with higher melting and printing temperatures have a bigger temperature gradient and stress than natural polymers. Besides, the mechanical strength of natural polymers is less when

Conclusion

In conclusion, 3D printing has emerged as a transformative force in many fields, including dental and biomedical applications. 3D printing can customize and precisely produce any complex structure that has revolutionized these fields. Moreover, ongoing research on heat sterilization and sintering has shown promise in improving the mechanical properties of 3D-printed biomedical and dental prototypes.

Overall, the 3D printing technique improves healthcare by introducing custom solutions for each individual. As technology improves, it can make healthcare more precise and individualized, leading to better treatment and healthier people worldwide.

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