Advances in the Use of 3D Printing for Semisolid Pharmaceutical Formulation Characterization

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01 INTRODUCTION

The characterization of semisolid pharmaceutical formulations is a critical component of topical drug development, particularly in the evaluation of in vitro drug release and permeation. Conventional testing systems, most notably glass-based vertical diffusion cells, are widely accepted but are often associated with high cost, limited flexibility, and practical constraints related to handling and customization. In this context, three-dimensional (3D) printing has emerged as an enabling technology that offers new opportunities for the design and implementation of experimental tools for semisolid formulation characterization.

02 METHODS

This work presents a narrative review of the current literature addressing the application of 3D printing technologies in the characterization of semisolid pharmaceutical formulations. The selection of studies was based on their methodological relevance, technological approach, and applicability to semisolid dosage forms.

03 RESULTS AND DISCUSSION

Recent advances in extrusion-based 3D printing, especially fused deposition modeling (FDM), have enabled the fabrication of customized vertical diffusion cells and related accessories using thermoplastic polymers such as polylactic acid (PLA) and polypropylene. These materials provide adequate mechanical strength, chemical stability, and reproducibility while allowing rapid prototyping and low-cost production. The increasing use of bio-based polymers, particularly PLA, further supports the alignment of 3D printing with sustainability-oriented trends in pharmaceutical research. Published studies indicate that properly designed 3D-printed diffusion systems can meet pharmacopeial requirements and exhibit performance comparable to commercially available glass cells in in vitro release and permeation testing. The adaptability of 3D printing allows modification of cell geometry, membrane support, diffusion area, and thermostating concepts, enabling tailored experimental setups for different semisolid dosage forms.

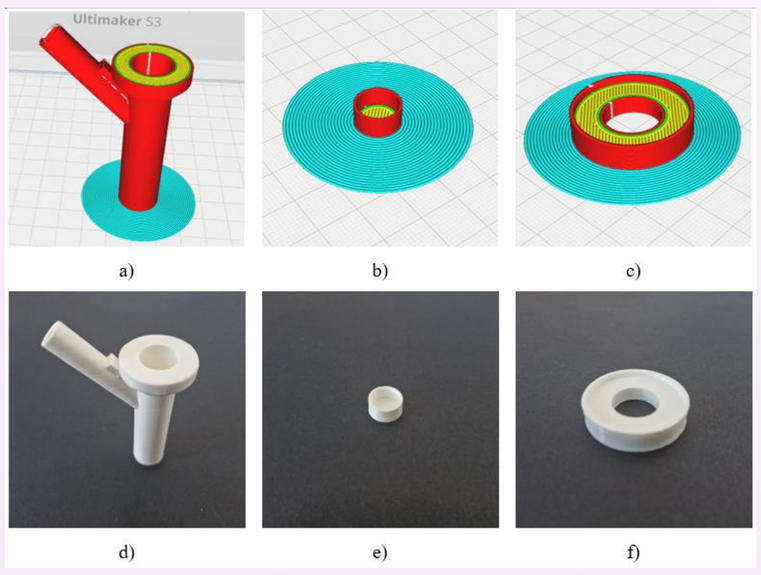

Figure 1. FDM 3D printed Franz cells [1]

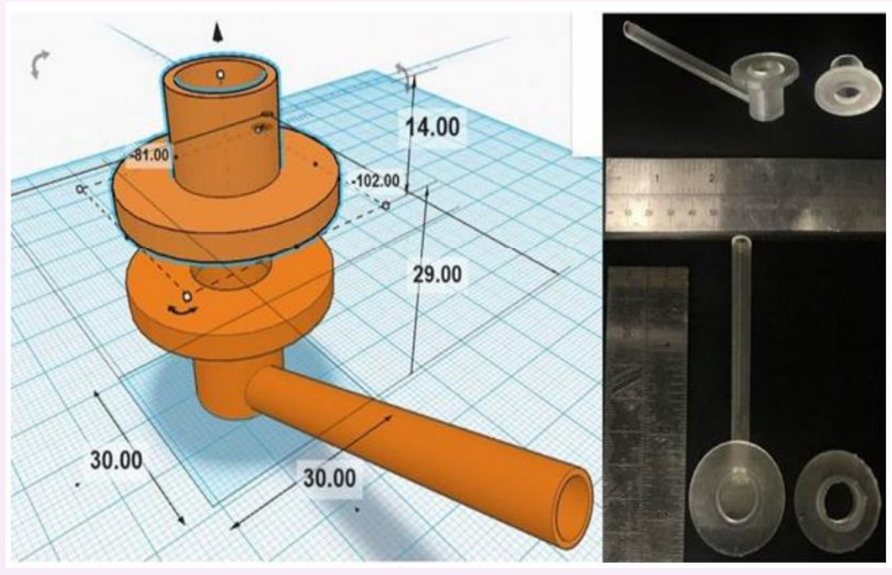

Figure 1. SLA 3D printed Franz cells [2]

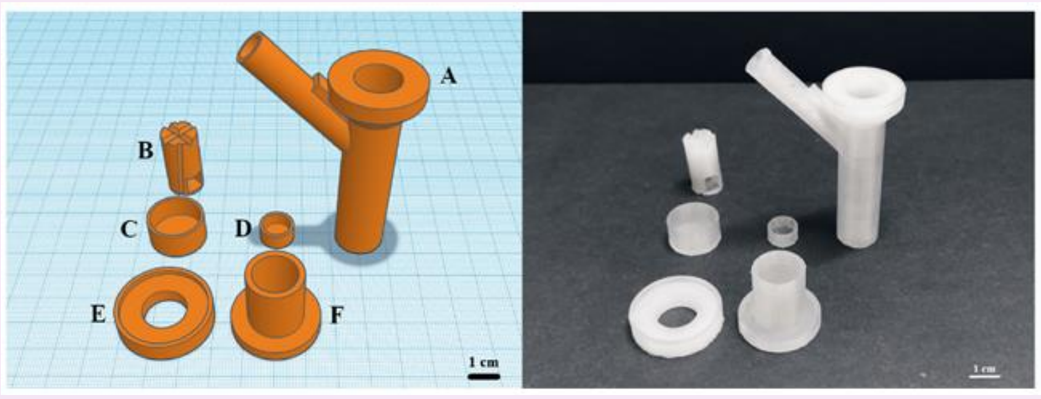

Figure 3. FDM 3D printed Franz cells [3]

Table 1. Journal parameters

Journal	Year of publication	IF5*	M category*
Therapeutic Delivery	2025	3.7	M21
International journal of cosmetic science	2018	1.928	M22
Journal of Drug Delivery Science and Technology	2021	4.624	M21

*highest value in the year of publication and the two preceding years

04 CONCLUSION

Overall, the application of 3D printing in the characterization of semisolid pharmaceutical formulations represents a significant methodological advancement. By providing customizable, cost-effective, and reproducible alternatives to conventional testing equipment, 3D printing has the potential to enhance in vitro evaluation strategies and accelerate the development of topical pharmaceutical products.

REFERENCES

1. Todorović N, Krstonošić V, Milijašević B, Đanić M, Ćoškov A, Vesković D, Lalić-Popović M. Innovative evaluation of topical simvastatin using 3D printed Franz-type cells and rheological testing. Therapeutic Delivery. 2025 Dec 18:1-2.
2. Sil BC, Alvarez MP, Zhang Y, Kung CP, Hossain M, Iliopoulos F, Luo L, Crowther JM, Moore DJ, Hadgraft J, Lane ME. 3D-printed Franz type diffusion cells. International journal of cosmetic science. 2018 Dec;40(6):604-9.
3. Tiboni M, Curzi G, Aluigi A, Casettari L. An easy 3D printing approach to manufacture vertical diffusion cells for in vitro release and permeation studies. Journal of Drug Delivery Science and Technology. 2021 Oct 1;65:102661.

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