STEREOLITHOGRAPHIC APPARATUS EVOLUTION: ENHANCING THROUGHPUT AND EFFICIENCY OF PHARMACEUTICAL FORMULATION DEVELOPMENT

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Background: Pharmaceutical additive manufacturing, also known as 3D printing, is a rapidly evolving set of technologies used to produce revolutionary drug delivery devices overcoming the limitations of conventional tableting techniques. The flexibility of 3D printing opens the way to personalised dosage forms, thus shifting from a one-size-fits-all approach to patient-centric medicine. Stereolithography (SLA) 3D printing, a vat photopolymerisation technique, has emerged as an attractive tool in pharmaceutics for the fabrication of controlled release tablets and polypills and offers a range of advantages over other technologies. However, the limited number of biocompatible photopolymers suitable for SLA coupled with the large amount of material required for a single print and its related cost hold back the further development of such technology. Hence, in this work we aimed to develop a novel Stereolithography apparatus specifically designed for high-throughput screening of pharmaceutical photopolymer formulations; an analysis on the cost effectiveness of the new SLA apparatus was also performed.

Methods: A novel build platform and resin tank inserts prototypes were designed using TinkerCAD and fabricated with a Form 2 SLA 3D printer using Clear photopolymer resin. The final build platform was manufactured through CNC milling of aluminum. The modified parts were subsequently assembled on the Form 2 3D printer and tested to fabricate cylindrical tablets previously designed using TinkerCAD. Three tablet batches, each of 10 units, were printed both on the original and the modified platform and evaluated according to uniformity of weight and thickness. Batches of the same tablet design were printed both with and without supports in order to assess printability outcomes and related material wastage. A time-dependent investigation on the photopolymer resin's loss due to adherence on the build platform after printing was carried by measuring the amount of resin adhering on the platform at different time points between 0 and 3600 seconds. An estimate of the cost implications of such waste was eventually calculated.

Results: The original resin tank having a capacity of 200 mL was modified to operate with only 10 mL of photopolymer resin. Moreover, the novel tank can contain up to 12 different resin formulations. As a result, the novel SLA apparatus we developed will allow us to maximise the formulation development process efficiency. Tablet uniformity data obtained from the modified build platform were comparable to the original platform. The use of supports to print tablets was found to significantly impact the generation of waste. Finally, the recovery of photopolymer resin adhering onto the build platform was found to reach a plateau at 2700 seconds for the original platform and at 1200 seconds for the modified platform. The percentage of resin recovered from the original and the modified platform at such time points was 63.04% and 44.77%, respectively.

Conclusions: A novel stereolithography apparatus was developed to carry a high efficiency screening of pharmaceutical photopolymer formulations. Such SLA apparatus was successfully tested to prove its reliability. Potential areas of wastage were investigated and mainly identified in relation to the use of printing supports and loss of resin adhering onto the build platform after printing. The latter issue was addressed by waiting for an hour of time allowing the maximum resin recovery. This could have significant implications in clinical applications of SLA 3D printing where cost-efficiency and high production rates must be met.