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Printfills: 3D Printed Systems Using Fused Deposition Modelling and Injection Volume Filling

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Introduction: Fused deposition modelling (FDM) has become a very attractive technology for development of pharmaceutical systems. Drug release profiles from FDM printed tablets are easily controlled by varying factors such as geometry, polymer selection or drug load. However, FDM has the limitation of the impossibility to print thermally sensitive drugs and the need to incorporate the drug to the polymeric filament as a previous step of manufacture. We hypothesize that the integration of FDM with Injection Volume Filling (IVF), which allows incorporating solutions/dispersions at room temperature to the extruded scaffold, could offer an easy, automatized and versatile technology to manufacture tailored drug delivery platforms [1].
Aims: The aim of this work was to design and characterize colon-specific drug delivery systems manufactured in a simple and automated 3D printer which combines two different 3D printing technologies FDM and IVF. This new kind of printed pharmaceutical dosage forms have been called *printfills*: printed systems filled with a liquid or semisolid.
Method: Polylactic acid was used as printer filament for FDM (Leon3D, Spain). Anhydrous theophylline (Acofarma, Spain) and Eudragit FS30D (Evonik, Germany) were used as model drug and delaying release polymer, respectively, for IVF. Printfills were manufactured with a REGEMAT 3D V1 printer (Spain) with FDM and IVF. A hydroalcoholic drug gel was injected in the extruded structure and Eudragit FS30D dispersion was incorporated into the top layer of the structure. Printfills were characterized from a physical and biopharmaceutical point of view, including SEM microscopy (FEI Teneo) and drug release modeling.
Results: 3D printed systems have been successfully performed using FDM and IVF (Fig.1). Results from drug release studies performed at different pH confirm the ability of printfills for colon-specific drug delivery. SEM microphotographs of printfills show the sealing of the structure in the perimeter and the homogeneity of the colonic film formed in the upper side. The obtained results indicate that, after the lag time, drug is released with an intermediate kinetics between zero order and diffusional kinetics, as shown by Korsmeyer time exponent (n=0.8749).

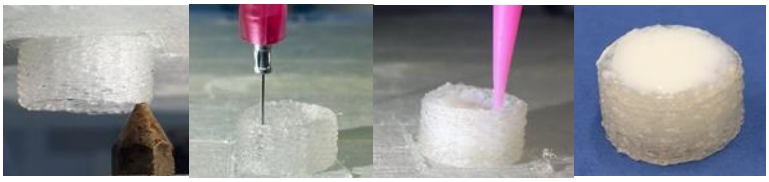

Fig. 1. From left to right: FDM extruder (PLA), IVF injecting drug–loaded gel, IVF injecting the delaying release polymer and final printfill obtained [1]

Conclusions: Pharmaceutical dosage forms have been manufactured for the first time with a 3D printer combining FDM and IVF. The integration of these two techniques allows an easier incorporation of drug/excipient liquid systems to the extruded scaffold at room temperature, avoiding other intermediate processes. *In vitro* studies show the ability for colon specific drug delivery of the performed printfills [1].

Keywords: 3D printing, fused deposition modelling, injection volume filling, colon specific release

Reference:
[1] Linares V, Casas M, Caraballo I. Eur J Pharm Biopharm 2019; 134: 138–143.