# RAPID PROTOTYPING FOR MATERIAL TESTING AND PROCESSING OF PARTICULATE PHARMACEUTICALS USING 3D PRINTING

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Three-dimensional (3D) printing is a rapidly developing area within additive manufacturing that has been broadly implemented in several industries. Recently, 3D printing has also attracted increased interest in the pharmaceutical field and ground-breaking examples of biomimetic structures (e.g. organ transplants) and drug delivery systems provide fundamental knowledge for the whole medical field [1]. However, pharmacopoeia-based drug product assessment and introduction of new manufacturing principles are heavily regulated areas and can be a showstopper for this progressive development. 3D printing for material testing and fabrication of process equipment has the advantage of being fast, inexpensive and adjustable according to the specific needs, such as incorporating interfacing for process analytical technologies (PAT). This study investigates 3D printing as a tool to design and develop geometries useful for material testing and processing of pharmaceuticals.

Examples related to powder flow characterization and particle engineering will be presented. The first example is related to the application of 3D printing for designing different funnel geometries to simulate and visualize various flow patterns of powders. Powder may flow in different patterns depending on the hopper geometry, and especially the outer angle of the lower part of the funnel has a significant contribution to the flow behaviour. This study investigates a number of funnels, designed to show different flow patterns. The flow will be simulated *in silico* and tested experimentally. The funnels are designed with the same top and outlet diameter, while modifications to the outer angle of the conical part of the hopper are implemented. The flow of the powders will be monitored and analysed using different PAT tools. Furthermore, the wall friction is assessed using the Schulze ring shear tester in order to predict the flow behaviour of the powder within the 3D printed funnel. The second example is related to particle engineering and specifically, *in silico* design and 3D printing of flow geometries for controlled particle formation in microfluidic geometries. Printed micromixer devices are used for high-throughput production of pharmaceutically relevant particles. Flow parameters are used to control the quality attributes of the prepared particles allowing increased control and improved reproducibility compared with manual mixing and enhanced cost-effectiveness and scalability compared other micromixers.

[1] B.C. Gross, J.L. Erkal, S.Y. Lockwood, C. Chen, D.M. Spence, Evaluation of 3D printing and Its Potential Impact on Biotechnology and the Chemical Sciences, Analytical Chemistry 86 (2014) 3240-3253