3D Scanning and SLA 3D Printing for Manufacturing Topical Drug Delivery Systems Tailored to Individual Patients
J. Wang, A. Goyanes, U. Det-Amornrat, A. Basit, S. Gaisford
University College London

Purpose
3D printing (3DP) is an additive manufacturing process that allows the fabrication of solid objects of virtually any shape from a 3D model. 3D scanning technology can be used to obtain 3D models adapted to the morphology of an individual. In stereolithography (SLA) printing, drug-containing solutions can be solidified by the action of a laser beam to create a solid object. To our knowledge, there has been no demonstration on the use of 3D scanning and SLA printing to manufacture personalized topical drug delivery systems. Here, the feasibility of printing anti-acne patches/masks personalized to the anatomy of an individual by 3D scanning and SLA 3DP was evaluated.

Methods
3D scanning was performed with Sense™ 3D scanner (3D Systems Inc., USA) to obtain a 3D model. Polyethylene glycol diacrylate (PEGDA) and Polyethylene glycol (PEG) 300 were mixed in ratios of 40:60 or 80:20 (v/v) with a photoinitiator at a concentration of 1% (w/v). Salicylic acid was then added to the solution to a concentration of 2% (w/w). Personalized devices were fabricated with the previously prepared solutions using a commercial Form 1+ Stereolithography 3D printer (Formlabs Inc, USA). The templates used to print the dressings were obtained by 3D scanning and exported as a stereolithography file (.stl) into the 3D printer software.

Drug permeation tests from the 3D printed flat patches were conducted using Franz cells with cellulose nitrate membranes.

Results
3D scanning technology easily allowed obtaining a 3D model of a nose adapted to the morphology of an individual. The 3D printer was found to produce personalized-shape drug loaded devices that would be difficult to obtain by traditional manufacturing methods. Drug loading was similar to the theoretical drug loading, indicating that no drug was degraded during the 3D printing process.

Drug diffusion tests show that drug permeation occurs slowly, as expected from a topical drug delivery device. Cumulative percentage of drug diffused from the printed PEGDA/PEG patch with higher amount of PEG is similar to that with lower amount of PEG during the first 2h and then diffusion is faster from patches with higher amount of PEG. The possible explanations are the PEG gets dissolved in the dissolution media, originating pores that let the media have access to more internal regions of the devices easier and faster than in the less porous devices. The effect of the PEGDA/PEG ratio on drug dissolution rate was previously described for oral tablets prepared by SLA printing.

Conclusion
The feasibility of using 3D scanning and SLA 3DP to fabricate drug-loaded devices for topical delivery of anti-acne drugs with no drug degradation has been demonstrated. They allowed obtaining personalized anti-acne masks with intricate shapes fully adapted to the anatomy of the patient. The results suggest that 3D scanning and SLA printing could offer a potential new method of manufacture for personalized-dose devices.