Investigation of Various Polymers for SLS 3D-Printing of Solid Oral Dosage Forms

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Purpose

- Selective laser sintering (SLS) is promising for printing oral dosage forms.
- Print ranges for commonly used pharmaceutical polymers not yet established for additive manufactured medications.
- Evaluate dedicated polymers for pharmaceutical applications.

Objectives

- Determination of optimal print conditions for various pharmaceutical-grade polymers (PVA 4-88 (Parteck® MXP), PVP-VA¹ (Kollidon VA64®), PVP-VA² (Plasdone™ S-630)).
- Usage conditions of dedicated PVA based polymers P1 (PVA3-82) and P2 (PVA5-74) in SLS printing and impact of hydrolysis degree on printing performance.

Methods

Materials and composition

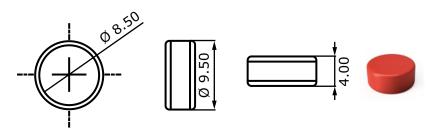
- 10% API (indomethacin)
- 88.5% polymer (PVA, PVP-VA¹, PVP-VA², P1, and P2)
- 0.5% excipient (silicon dioxide colloidal)
- 1% colorant (silica-based effect pigment)

SLS of dosage forms

36 tablet batches created with the same conditions:

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Layer Height (µm)	Perimeter Offset (µm)	Hatching Space (µm)	Hatching Offset (µm)	Number of Perimeters		
125	50	50	150	3		

- Prints done with three temperatures and three laser scan speeds: 75 °C, 100 °C, & 125 °C and 200 mm/s, 300 mm/s, and 400 mm/s, respectively.
- For some materials, 125 °C was too high, so 112.5 °C was used
- Tablets designed using Fusion360 modelling software:

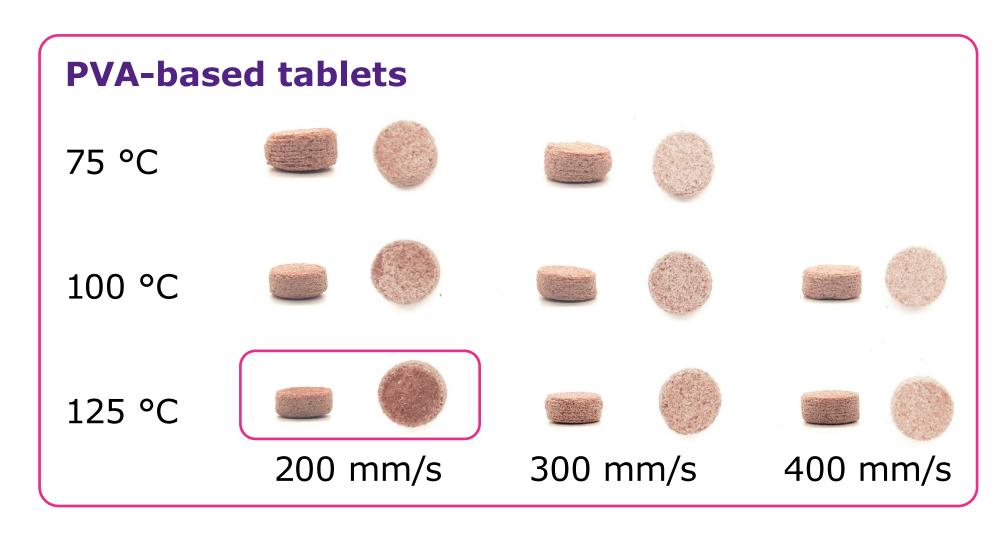


- Printing occurs in layer-by-layer fashion in print bed (tablets fully submerged in powder post-printing, collected via sieving, and dedusted).
- 2.3 W diode (λ =455 nm) laser used.

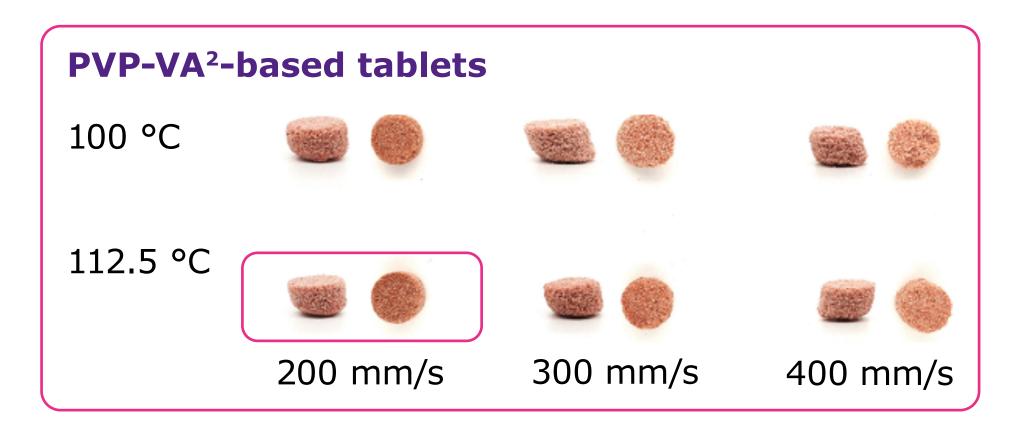
Characterization

• XRD, DSC, friability, mass and size analysis, HPLC, dissolution.

Results







- Evidence of amorphous nature in all of the best print condition samples for each polymer.
- Trends of lower temperature and high laser scan speeds showed more evidence of crystallinity of the API.

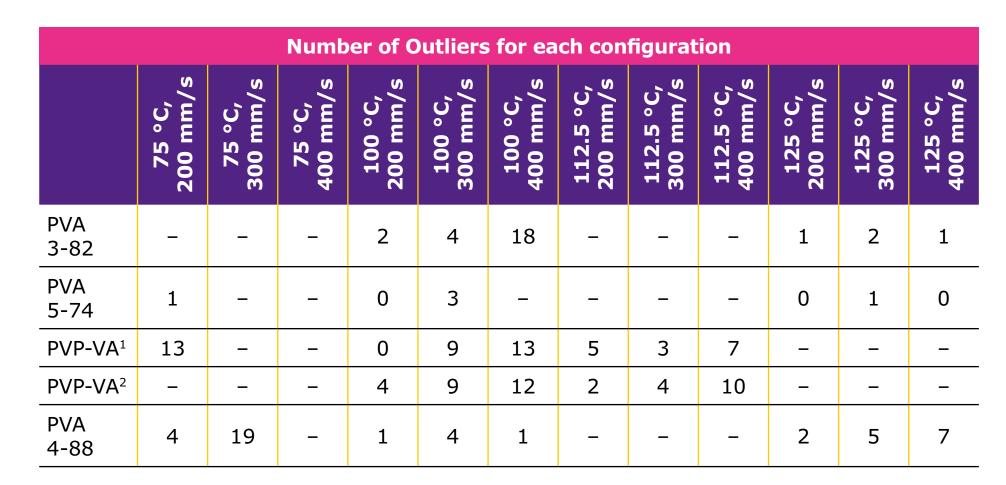
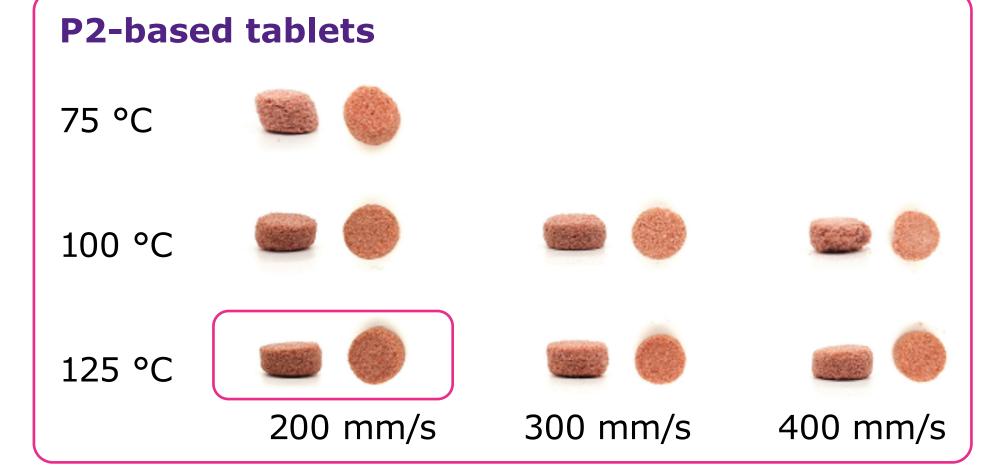


Table 1. Number of outliers for each printed batch, with less outliers being the ideal case.

100 °C 125 °C 400 mm/s 300 mm/s 200 mm/s

P1-based tablets



- Printable tablets for each of the polymers tested with the best print by characterization and visual standard indicated via a red box.
- Tablets exhibit higher level of sintering at lower laser scan speeds and higher temperatures (within an appropriate temperature window).
- Mass deviation for the tablets with the best print parameters fell within Ph. Eur. 2.9.5-Uniformity of Mass of Single-Dose Preparation standards for traditional tablets.
- Number of outliers for tablets with the best print parameters did not always meet Pharmacopeia requirements (<2 outliers), but all viable samples were measured (standards require just 20 at random).
- Friability, while not fully meeting Ph. Eur. criteria for traditional tablets, performed well in some cases, especially for PVA-based tablets.

	Friability comparison of each identified configuration													
P1	_	-	_	12.0	51.9	_	_	_	_	2.3	9.3	22.9		
P2	-	1	_	11.0	-	_	_	_	_	4.5	9.5	15.9		
PVP-VA ¹	_	_	_	7.8	34.9	_	4.1	_	_	_	_	_		
PVP-VA ²	_	_	_	7.0	_	_	4.5	22.6	_	_	_	_		
PVA	11.2	_	_	4.3	20.2	_	_	_	_	2.0	9.1	-		

Table 2.

Friability for each printed batch, with lower friability being the ideal case.

Conclusions

- Higher temperatures within the print window for the polymers and lower laser scan speeds within the range tested generally led to superior samples.
- PVA based polymers were able to perform within a broad processing window (75–125 °C), whereas PVP-based polymers tested show an optimal upper limit of 112.5 °C.
- Best friability results were obtained using PVA grades.
- Most robust samples per batch tended to meet or come close to meeting current Pharmacopeia standards for traditional oral dosage forms.

Funding

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References

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