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Optimization of Manufacturing Parameters of 3D Printed Solid Microneedles for Transdermal Drug Delivery

micromachines MDPI

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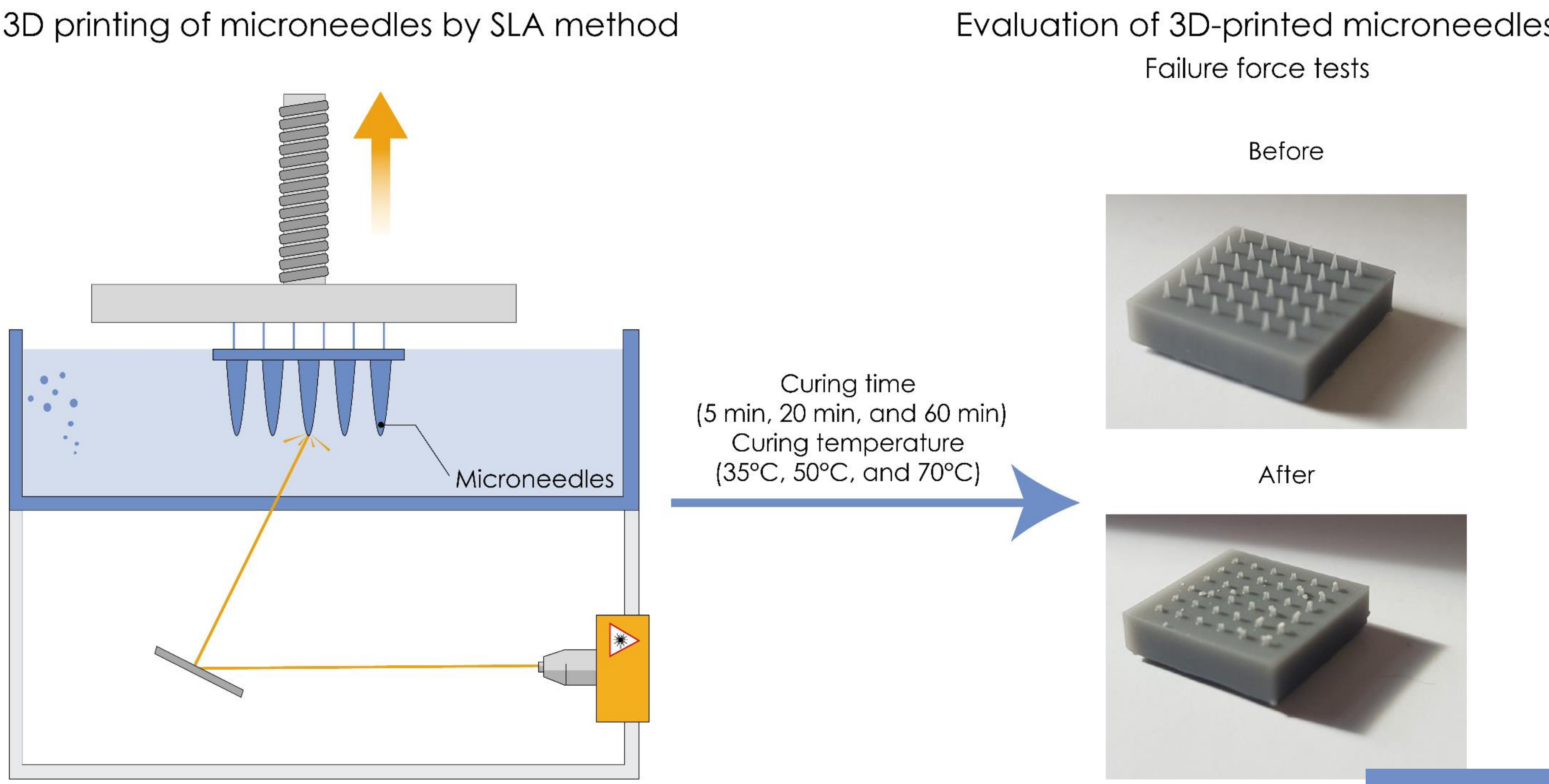

Graphical abstract

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- Microneedles (MNs) have been manufactured using a variety of methods from a range of materials, but most of them are expensive and time-consuming for screening new designs and making any modifications [1].

- Therefore, stereolithography (SLA) has emerged as a promising approach for MN fabrication due to its numerous advantages, including simplicity, low cost, and the ability to manufacture complex geometrical products at any time, including modifications to the original designs [1].

- This work aimed to print MNs using SLA technology and investigate the effects of post-printing curing conditions on the mechanical properties of 3D-printed MNs.

- **Keywords:** microneedles; 3D printing; stereolithography; optimization; transdermal drug delivery

[1] Tucak, A.; Sirbubalo, M.; Hindija, L.; Rahić, O.; Hadžiabdić, J.; Muhamedagić, K.; Čekić, A.; Vranić, E. Microneedles: Characteristics, Materials, Production Methods and Commercial Development. *Micromachines* **2020**, *11*, 961.

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Materials and Methods

- **Printing of microneedles with SLA printer**
- Solid MNs were designed using CAD software and printed with grey resin (Formlabs, UK) using Form 3 printer (Formlabs, UK).
- MNs dimensions were 1.2 × 0.4 × 0.05 mm, arranged in 6 rows and 6 columns on a 10 × 10 mm baseplate. MNs were then immersed in an isopropyl alcohol bath to remove unpolymerized resin residues and cured in a UV-A heated chamber (Formalabs, UK).
- In total, nine samples were taken for each combination of curing temperature (35°C, 50°C, and 70°C) and curing time (5 min, 20 min, and 60 min).

Fig 1. Form 3 printer

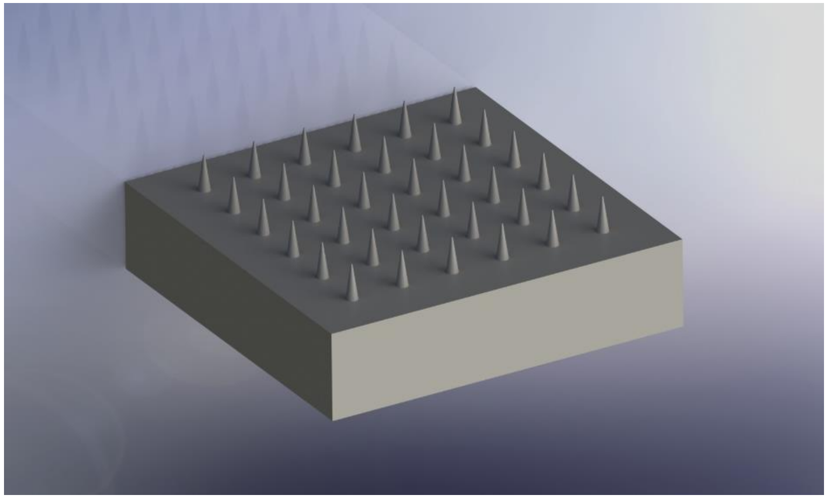

Fig 2. Microneedle model

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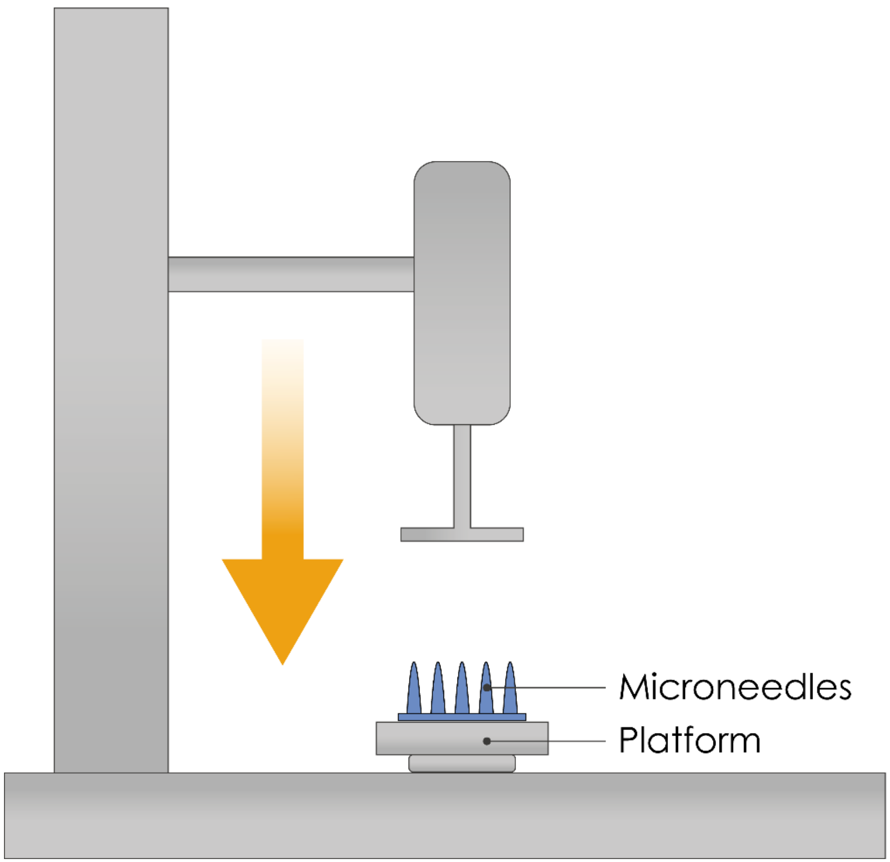
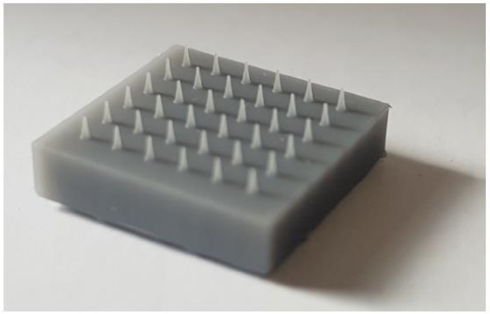
Materials and Methods

- **Fracture test**
- Fracture tests were conducted using a hardness apparatus TB24 (Erweka, Germany).
- MNs were placed on the moving probe of the machine and compressed until fracture.



Before



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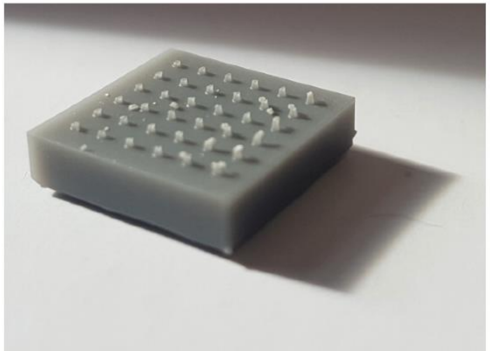

Fig 3. Fracture test

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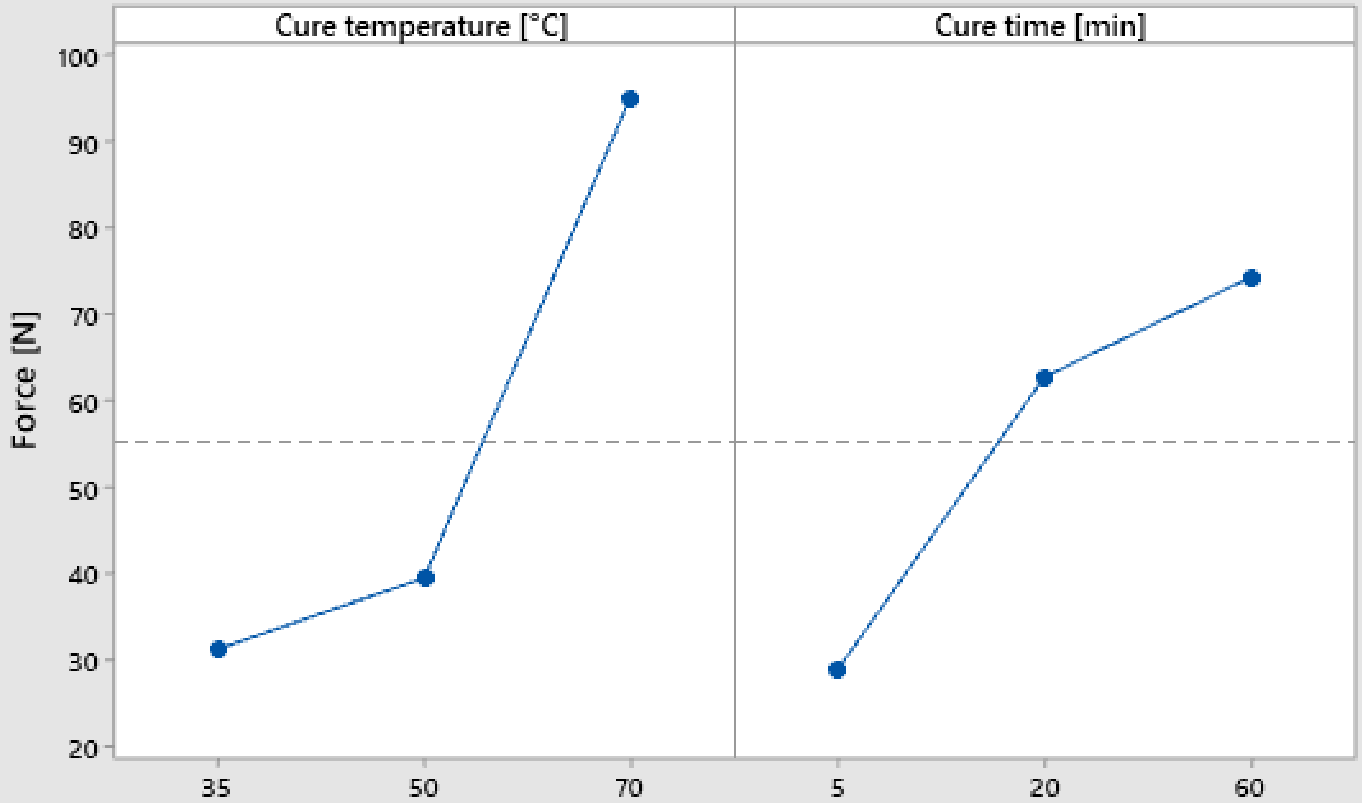
Results and Discussion

The optimization of the SLA process parameters for improving the strength of MNs was performed using the Taguchi method. The design of experiments was carried out based on the Taguchi L9 orthogonal array.

Fig. 4. Impact of temperature and cure time on fracture force



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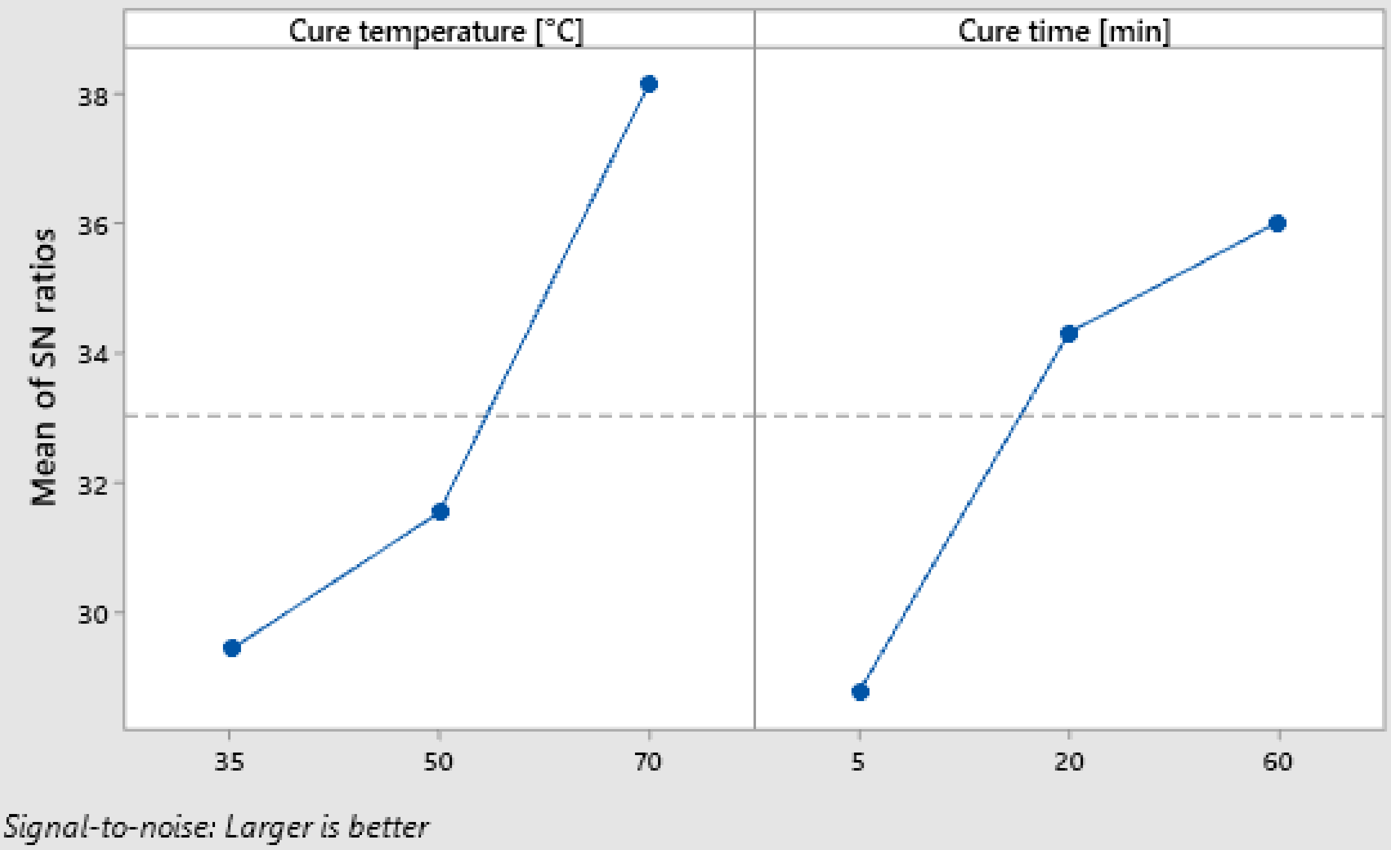
Results and Discussion

The optimization of the SLA process parameters for improving the strength of MNs was performed using the Taguchi method. The design of experiments was carried out based on the Taguchi L9 orthogonal array.

Fig. 5. Signal-to-Noise ratio for cure temperature and cure time



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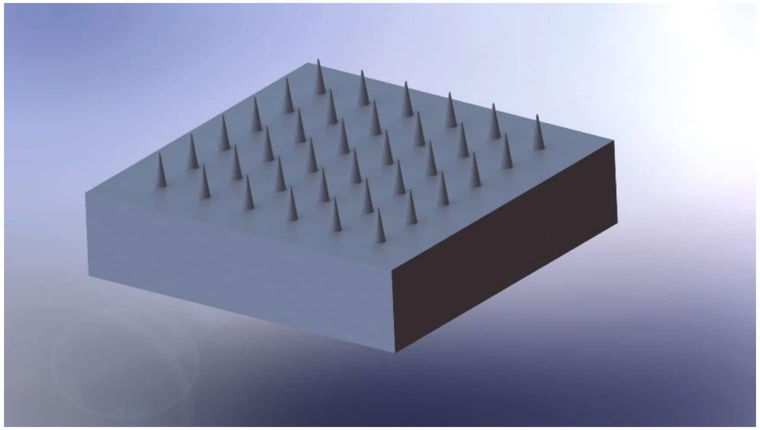
Conclusion

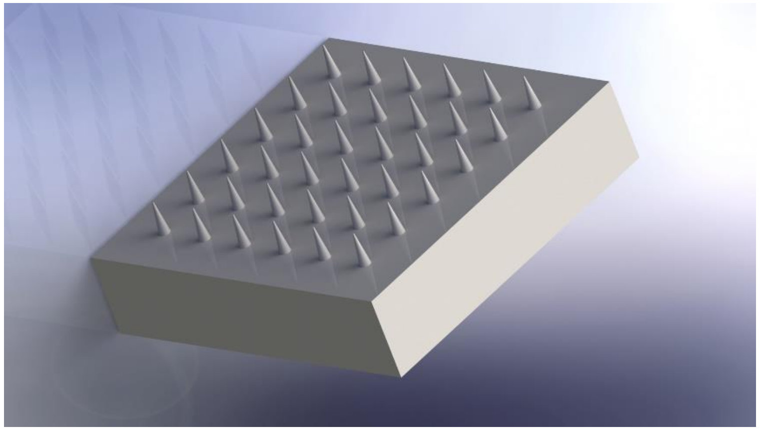
All nine types of microneedles were **successfully printed** using the SLA printer

Experimental results showed that the curing temperature has a **significant influence** on MN strength improvements.

Improvement of the MN strength can be achieved by **increasing** the curing temperature and curing time.

Further investigations: The effect of printing angle on sharpness and material mechanical properties of SLA-printed microneedles.





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