3D Printing: an emerging technology to personalize the delivery of cosmetics actives from topical patches

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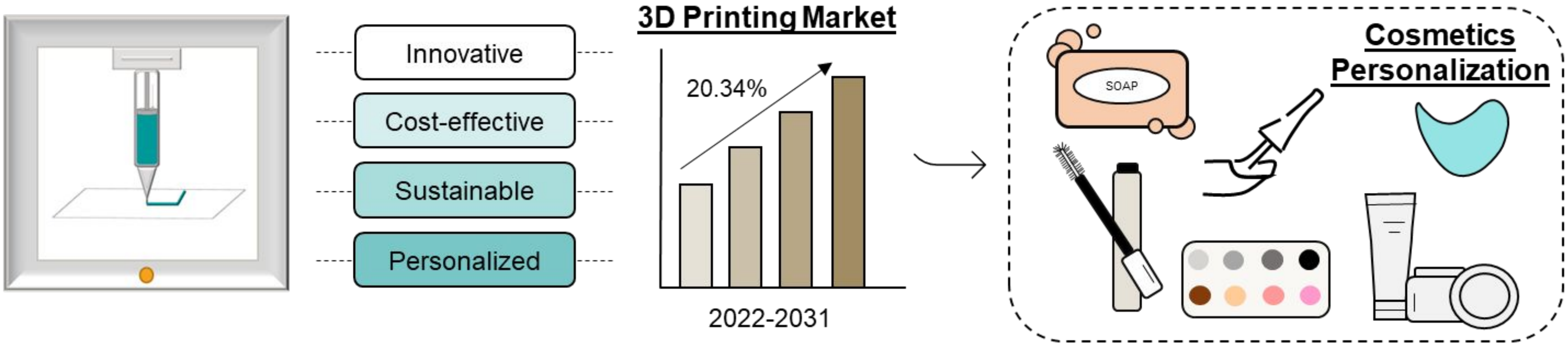
IPS Instituto Politécnico de Setúbal Escola Superior de Ciências Empresariais

FCT Fundação para a Ciência e a Tecnologia

Background

- **3D Printing: concept and application in skincare**

3D Printing: a reality in cosmetics? It is revolutionizing and disrupting the concepts of one-size-fits-all and one-treatment-fits-all.



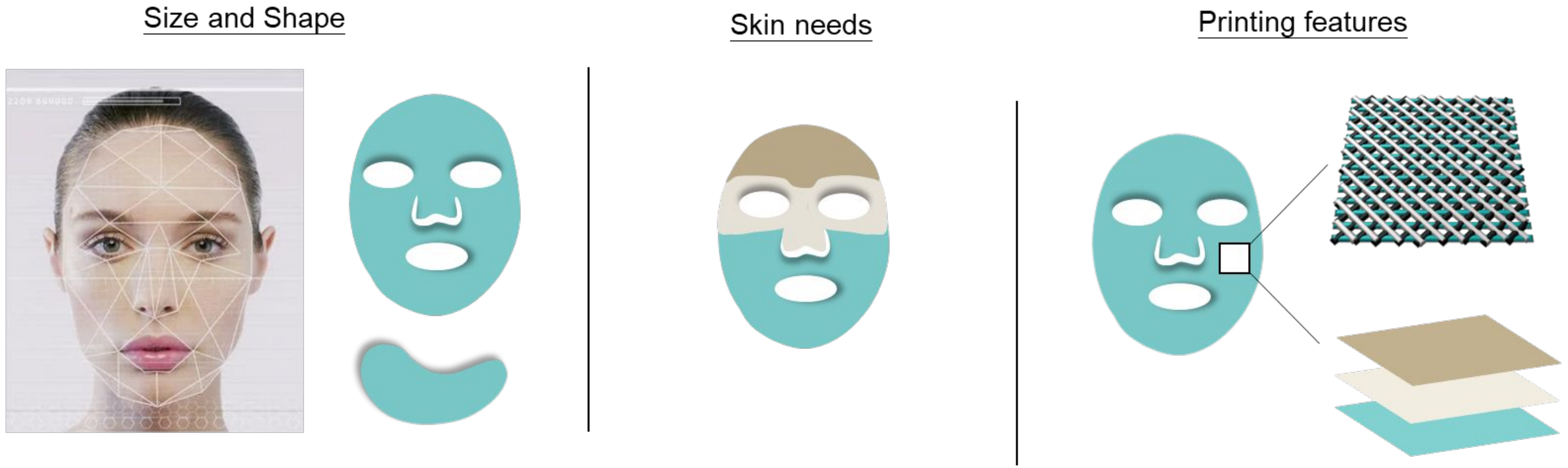
S. Bom, A.M. Martins, H.M. Ribeiro, J. Marto, Int. J. Pharm. 605 (2021) 1–20.
N.P. Kim, J. Kim, M.S. Han, J. Cosmet. Med. 3 (2019) 94–101.

Background

- **Personalization in skincare**

How hydrogel-based face masks can be **PERSONALIZED** through 3D printing?

The 3 Personalization approaches



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A. Goyanes, U. Det-Amornrat, J. Wang, A.W. Basit, S. Gaisford, J. Control. Release. 234 (2016) 41–48.

Outline and aims

Printing process optimization

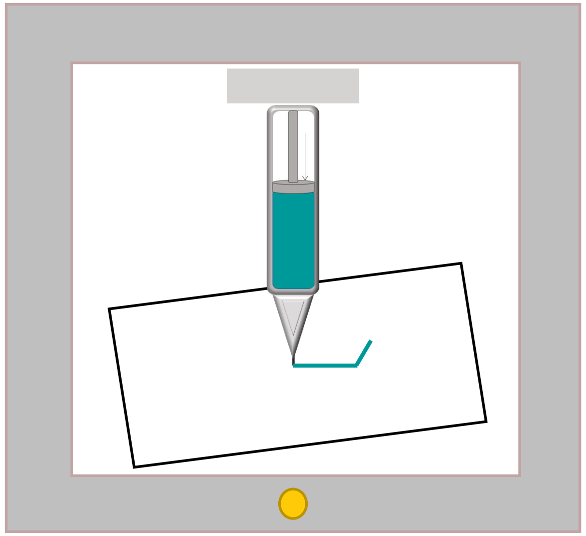
- Development of a 3D Printing tool

3D patches optimization and characterization

- Studying the effect of an anti-aging substance incorporation – Niacinamide (printing accuracy, porosity, topography and *in vitro* release)

Skin Patches Personalization – the concept

- Personalization of an eye patch considering different designs and skin needs
- *In vivo* penetration studies – Confocal Raman Spectroscopy

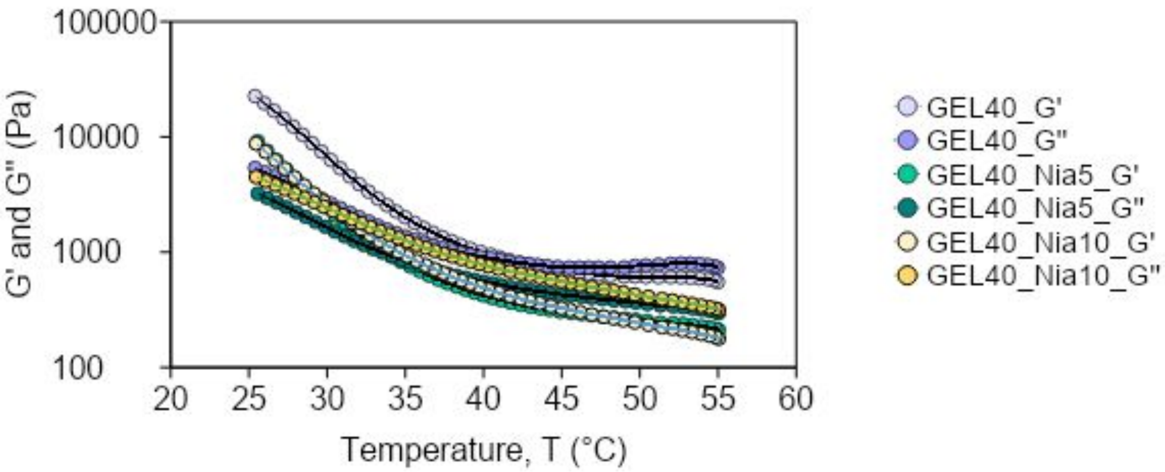


Patches Optimization and Characterization

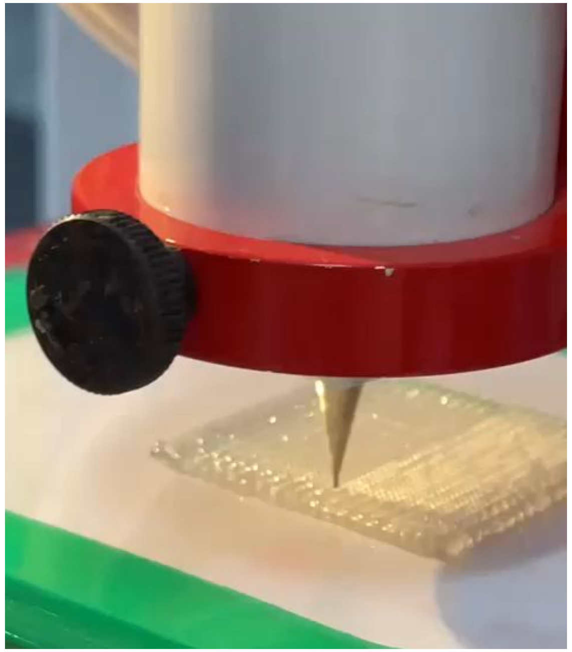
- **Pre-Printing relevance (From rheology to printing accuracy)**

  Kinexus Rheometer by Malvern Instruments (UK)

  Single frequency strain-controlled temperature ramp sequence: Plate-plate geometry; T=55 °C to 25°C; Frequency=1Hz; Ramp rate = 2.5°C/min



Formulations	Rheological Parameters (Mean ± SD; n=3)			
	Crossover (°C)	η at (Pa.s)		
		55 °C	Sol-Gel	25 °C
GEL40	42.4 ± 0.6	145.8 ± 18.5	181.8 ± 14.4	3695.0 ± 535.8
GEL40_Nia5	33.5 ± 0.1	57.9 ± 8.9	226.8 ± 31.6	1541.7 ± 158.9
GEL40_Nia10	30.4 ± 0.0	57.8 ± 5.5	526.0 ± 159.5	1568.0 ± 377.6



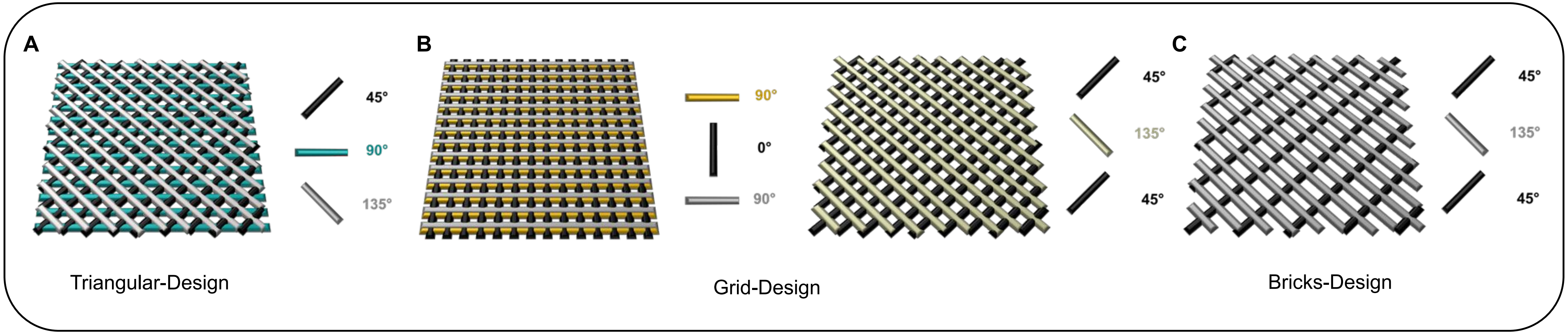
Control of Printing Settings

Nia, Niacinamide.

Printing Process Optimization

- **Development of a 3D Printing tool**

3-layered patches (20 mm × 20 mm × 0.45 mm) with different infill patterns were printed in an extrusion-based 3D printer (Allevi2, Allevi, USA) employing a 25G nozzle

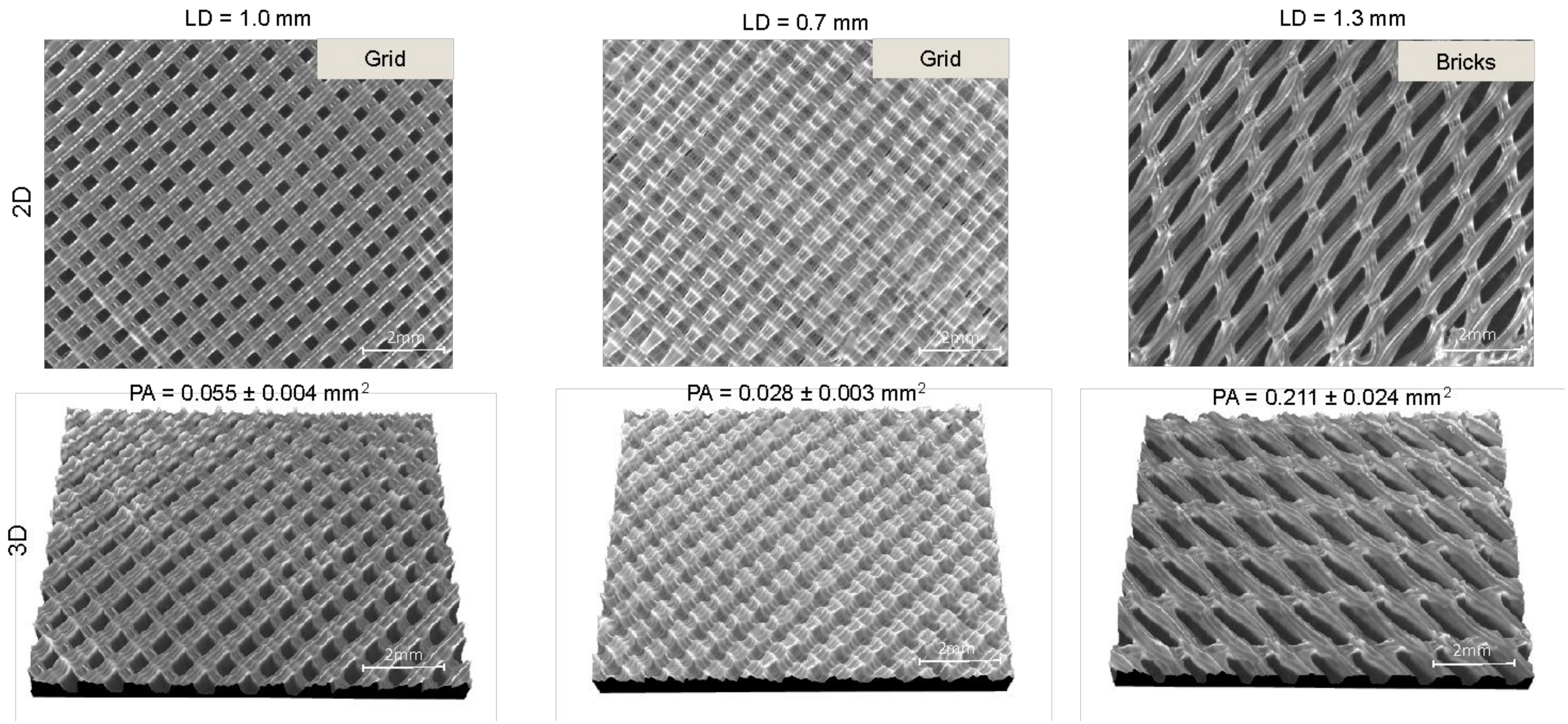


3D-printed patches

Printing Process Optimization

- **Development of a 3D Printing tool**

3-layered patches (20 mm × 20 mm × 0.45 mm) with different infill patterns were printed in an extrusion-based 3D printer (Allevi2, Allevi, USA) employing a 25 and 27G nozzle



It is possible to produce patches with different porosity degrees by changing the line distance and printing angle

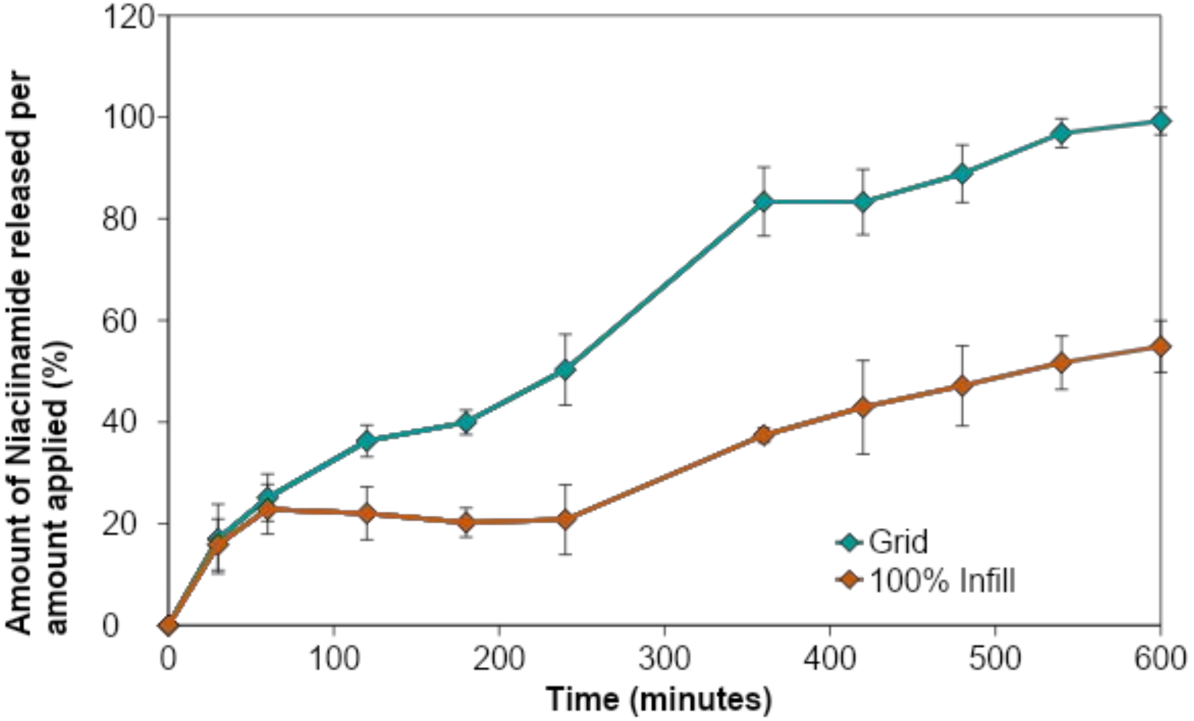
But why are these results relevant?

To modulate the release of bioactives

Patches Characterization

- ***In vitro* release**

Franz Cells system, 35ºC, 300 rpm (mean±SD, n = 6)



Porosity influenced niacinamide release, with the porous-designed patches showing a **44.3% increased release rate** compared to the occlusive ones, after 10h

The concept

Personalized skincare

Personalized skincare

- **Eye Patch personalization to the skin needs**

Visia-CA™: 2D skin analysis
AEVA: 3D skin analysis for designing the personalized eye patch

Skin analysis

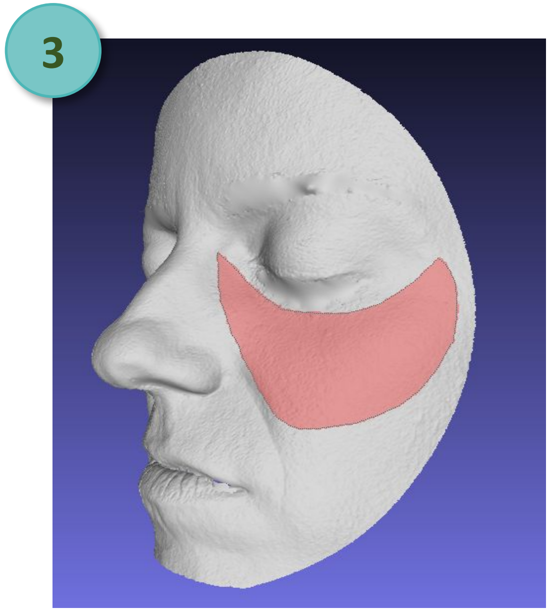
3D skin analysis

Personalized skincare

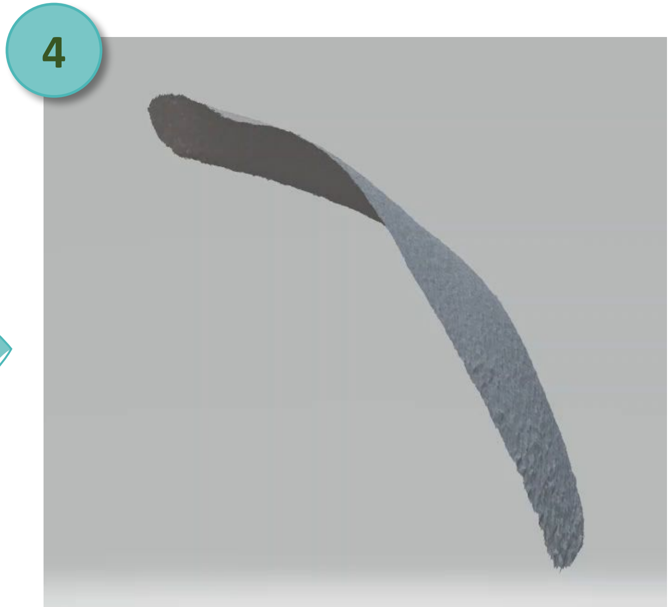
- **Eye Patch personalization to the skin needs**

Patch design: From 3D scanning (AEVA HE) to slicing (Ultimaker Cura software)

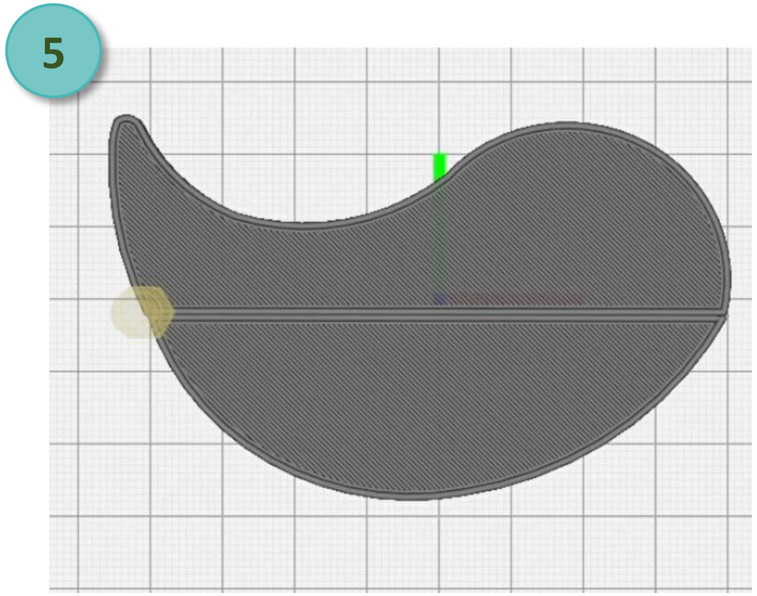
Defining the patch area



Extracting the 3D patch area



Flattening and Slicing

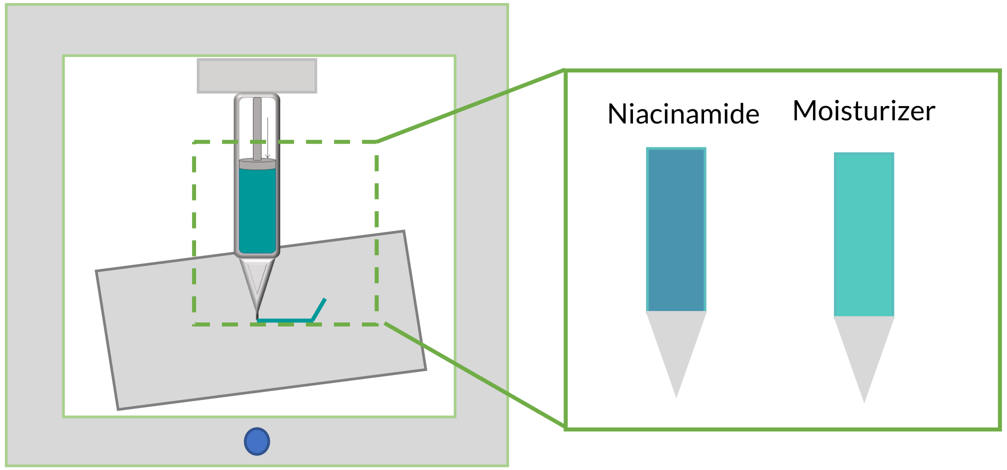


Personalized skincare

- **Eye Patch personalization to the skin needs**

  3-Layered grid porous patch containing 5% of Niacinamide and a moisturizer

6 Printing eye patch with different ingredients



3D printing strategies allows the incorporation of different ingredients within the same patch

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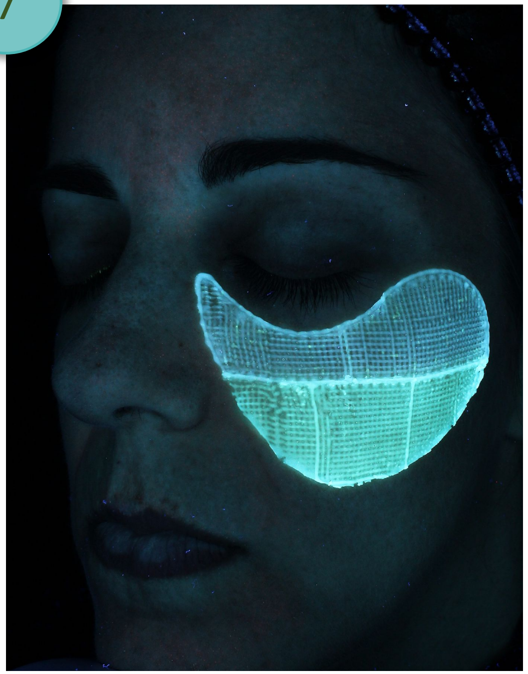
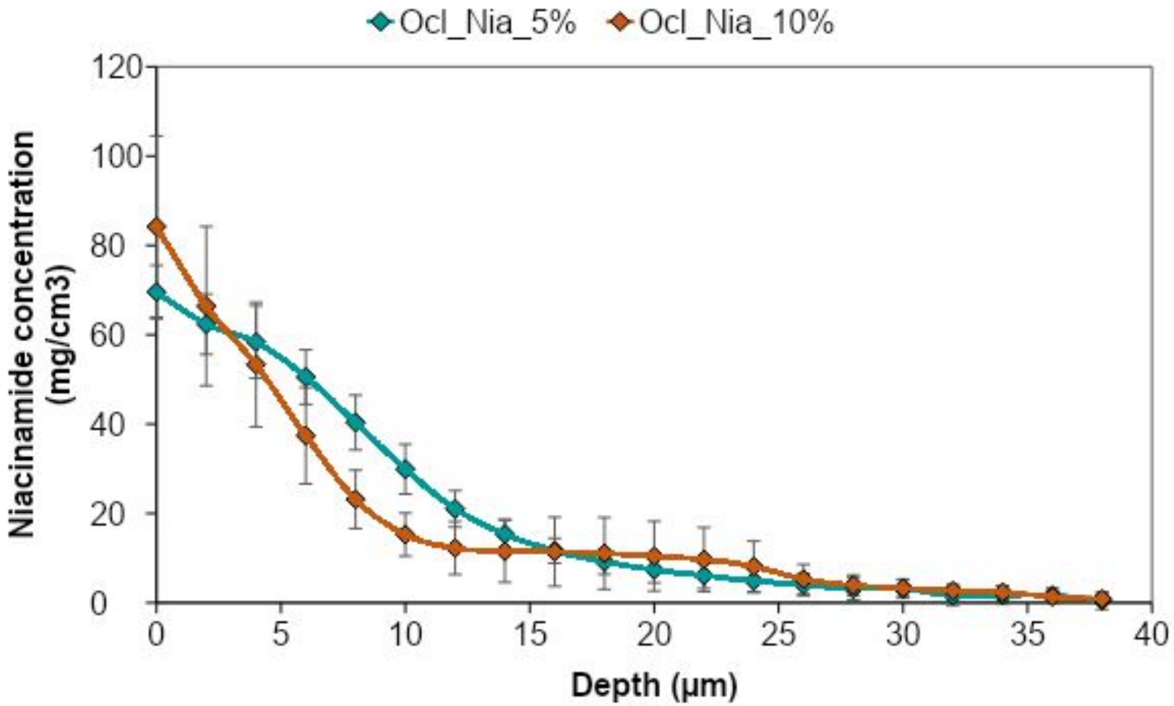


Personalized Patch

In vivo penetration

- **Confocal Raman Spectroscopy (CRS)**

CRS: Gen2-SCA, RiverD, Netherlands. n = 10 volunteers



The CRS *in vivo* data demonstrate that niacinamide <u>penetrated up to 38 µm independently of the concentration</u> (*stratum corneum*), showing a maximum penetration of **69.55 mg niacinamide/cm^3** and **84.23 mg niacinamide/cm^3**

Nia, Niacinamide.

Conclusions and Future Work

Highlights

- Insights into the practicality of using 3DP to modulate the compounds' release by employing straightforward construction design strategies;
- 3D printing technology offers the necessary versatility to quickly modify and adjust the vehicle to the different requirements of various skin conditions;
- Possibility of quantifying such effects *in vivo* opens a new prospective perspective to evaluate and adjust the cosmetic outcomes.

Ongoing and Future Work

- Explore *in vivo* the influence of different internal designs on the penetration profile;
- Incorporate different concentrations of niacinamide or mash-up different internal designs within the same patch structure according to the skin location needs.

Questions

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