# Development of a 3D-Printed Bio-Hybrid Skin Model for Photothermal Therapy Applications


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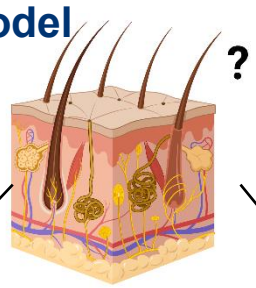
## 1. Goals

Aim of the PhD project:

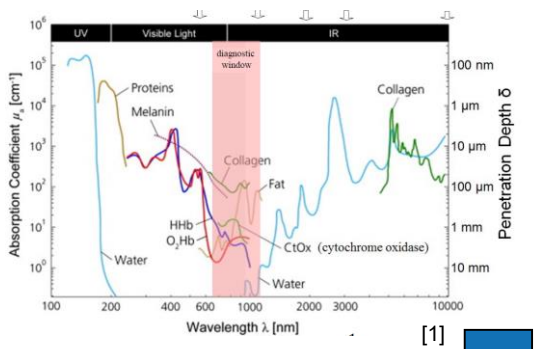
1. Developing a skin model that replicates the optical and thermal properties of human skin.
2. Investigation of the influence of skin structure on optical and thermal properties.
3. Integrating biological components, such as cells and hair follicle structures, into the synthetic skin model to simulate the complex biological responses during photothermal treatments.

## 2. Photothermal model




Optical properties

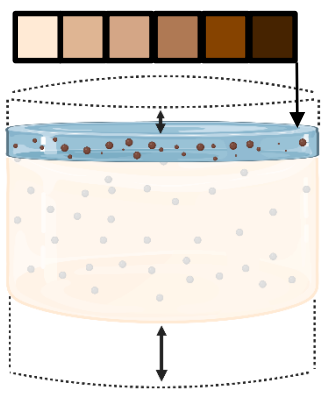
Thermal properties




[1]

- Thermal conductivity
- Specific heat capacity
- Thermal diffusivity
- Density

**Photothermal skin model**



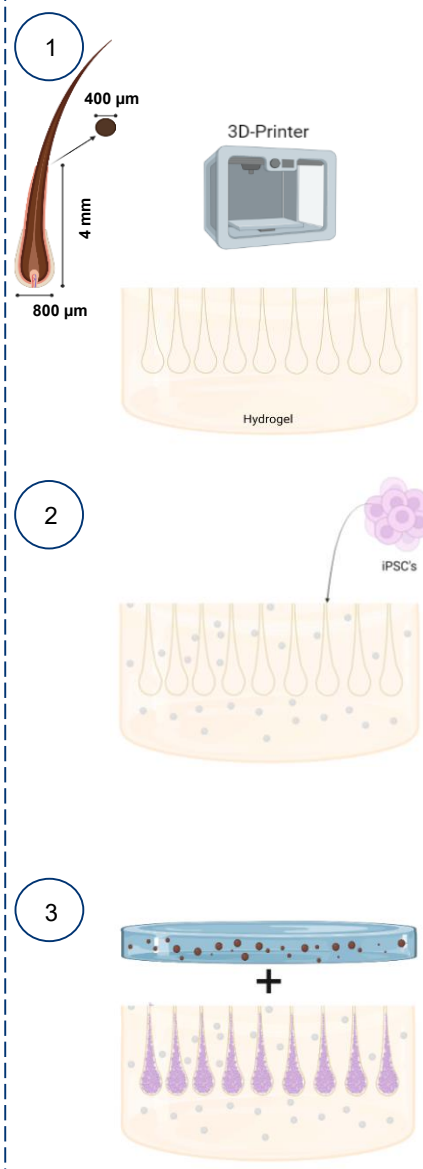
Epidermis equivalent

Dermis equivalent

**Concept:**
Mimick optical properties with scattering ($TiO_2$) and absorption material (Polydopamine).

**Goal:**
By changing the skin structures (thickness, skin colour), the influence of these on the optical and thermal properties and photothermal therapy will be determined.

## 3. Bio-hybrid model



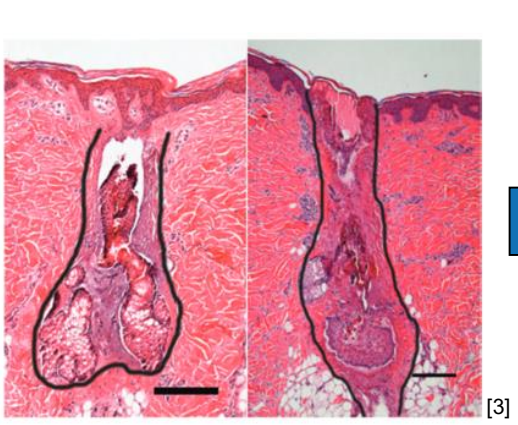

[2]

**3D-Printing:**
Stereolithograhic printing of microwells with high aspect ratio mimicking the hair follicle structure. Dermal equivalent hydrogel used as base material.

**Cell culturing:**
Seeding of dermal papilla cells and keratinocytes inside of the microwells.
Culturing and proliferation of the human hair follicle cells.

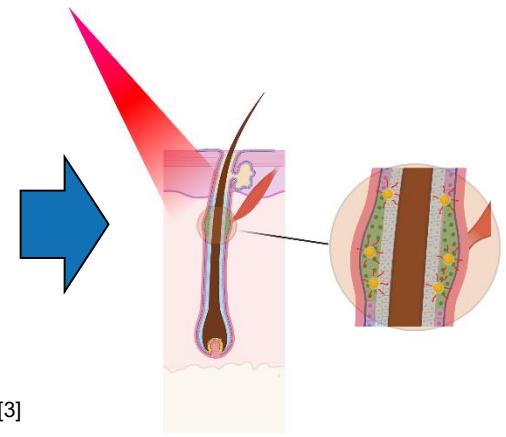
**Assembly:**
Permanent adhesion of epidermis equivalent with absorbent material and dermis equivalent with hair follicle structure and scattering material.

## 4. Application: Photothermal hair removal



[3]

**Gold nanoparticle acne removal**



**Gold nanoparticle hair removal**

- Integrate photothermal agents into cell structure, excite with infrared lasers, analyze temperature rise and cell degradation for hair removal.
- Demonstrate hair removal application using photothermal agents in bio-hybrid skin phantom.
- Study effects of photothermal applications on bio-hybrid structure's cells.

**Additional applications:**
Other photothermal therapy applications (PTT)
Photodynamic therapy (PDT)
Low level laser therapy (LLLT)


**References**

[1] F. Martin. Biomedical Photonics. Eidgenössische Technische Hochschule Zürich. Class lecture

[2] Abaci, H.E., Coffman, A., Doucet, Y. et al. Tissue engineering of human hair follicles using a biomimetic developmental approach. Nat Commun 9, 5301 (2018).

[3] Paithankar DY, et. al. Acne Treatment Based on Selective Photothermolysis of Sebaceous Follicles with Topically Delivered Light-Absorbing Gold Microparticles. J Invest Dermatol. 2015 Jul;135(7):1727-1734.



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