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Platelet-camouflaged nanoparticles delivered via 3D-printed microneedles for localized hair growth



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Androgenetic alopecia, the most common form of hair loss, is strongly associated with oxidative stress and alterations of the perifollicular microenvironment that impair follicle regeneration. While traditionally approached from hormonal and genetic perspectives, the perifollicular niche itself is often overlooked in therapeutic design. However, increasing evidence highlights the central role of this microenvironment in regulating hair growth, through oxidative balance, vascular support, immune cell activity, and extracellular matrix signalling. Precision therapies capable of reaching and remaining within this niche are therefore critically needed, as current topical and systemic treatments lack targeted delivery and show limited local retention. Here, we developed a biomimetic drug delivery platform combining platelet-camouflaged, resveratrol-loaded nanoparticles (RSV-NPs) with hollow 3D-printed microneedles (HMNs) for localized intradermal administration. The self-administered HMNs feature tunable lengths (1 mm and 1.5 mm), enabling controlled, depth-specific delivery. Mechanical characterization confirmed safe insertion, and histological analysis demonstrated penetration into the dermis and dermis-hypodermis interface, enhancing local retention of RSV-NPs within the skin layers. Platelet membrane cloaking increased nanoparticle size consistent with bilayer coating and preserved key membrane proteins, including CD42b (adhesion-related) and CD47 (immune evasion marker), supporting local retention and

reduced phagocytic clearance. Importantly, hair follicle elongation assays showed that this biomimetic NPs significantly enhanced hair shaft growth compared to control. This integrated nanotechnology-microneedle approach offers a targeted, minimally invasive strategy for localized antioxidant therapy in hair regeneration.

Short Bio

Renata Basto (RB) is a PhD student in Molecular and Cellular Biotechnology Applied to Health Sciences at the Faculty of Pharmacy, University of Porto (FFUP). Renata holds an Integrated Master's degree in Bioengineering and has participated in four research projects, including international research stays at the Stem Cell Institute Leuven (KU Leuven, Belgium), University of Greenwich (UK), and Universidad Carlos III de Madrid (Spain).

RB's research centers on nanotherapy applied to hair loss and skin aging, focusing on biomimetic nanoparticles from autologous blood sources to reshape the perifollicular niche and promote hair regeneration. Her approach integrates 3D-printed microneedles for targeted delivery of bioactive molecules, tested in human hair follicle assays and human dermal papilla cells.

RB has developed an interest in science communication, winning first place in the UP Doctoral Careers PhD Pitching Event (1st edition) and other communication awards. Renata is part of COST Action 21108, being a member of the Science Communication Team responsible for the organization's social media platforms.

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Webinar Host

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