Printed drug-loaded temporary tattoos – A novel, highly acceptable pre-treatment option for pain-free vaccination for children

M. Zettl[1]; M. Wolfgang[1]; L. Wiltschko[2]; R.Raml[2]; E. Roblegg[3]; S. Eder[1]; M. Spoerk[1]

[1] Research Center Pharmaceutical Engineering GmbH, Graz, Austria

[2] HEALTH – Institute for Biomedical Research and Technologies, Joanneum Research GmbH, Graz, Austria

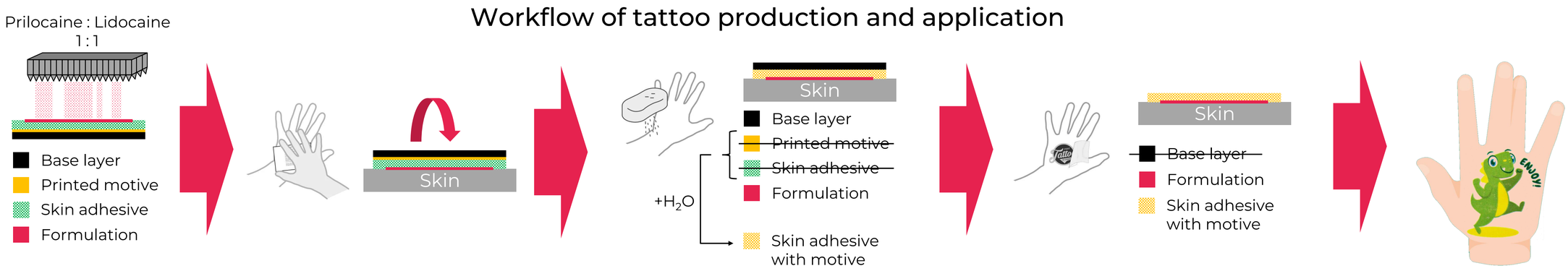
[3] University of Graz, Institute of Pharmaceutical Sciences, Pharmaceutical Technology and Biopharmacy, Graz, Austria

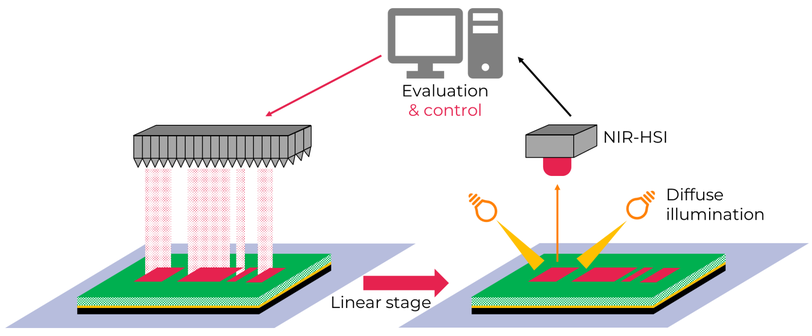
Introduction

Topical and transdermal applications provide significant advantages, including localized drug delivery and reduced side effects. However, conventional dosage forms like creams and sprays can be easily removed from the skin, affecting drug absorption. In contrast, patches offer precise, controlled dosing and serve as a promising alternative, particularly for children and patients who struggle with oral medication. Our study focuses on developing personalized transdermal patches with adjustable drug loading using temporary tattoos. These patches can feature decorative motifs (e.g., to enhance acceptance among children) or remain discreetly skin-colored or transparent.

Methods

A 1:1 eutectic mixture of prilocaine and lidocaine (10 wt.%) was dissolved in pure ethanol and used as ink in a piezo-driven inkjet printer. The ink was then printed onto commercially available temporary tattoo paper. By layering multiple prints on top of each other, the drug dosage could be adjusted within a 10 cm² surface area. The resulting tattoos were quantified in-line using a hyperspectral near-infrared (HS-NIR) spectrometer, and a quantitative model suitable for process and quality control was established. Additionally, these tattoos were applied to human abdominal skin explants, allowing measurement of drug concentration over time in both the upper and lower dermis.



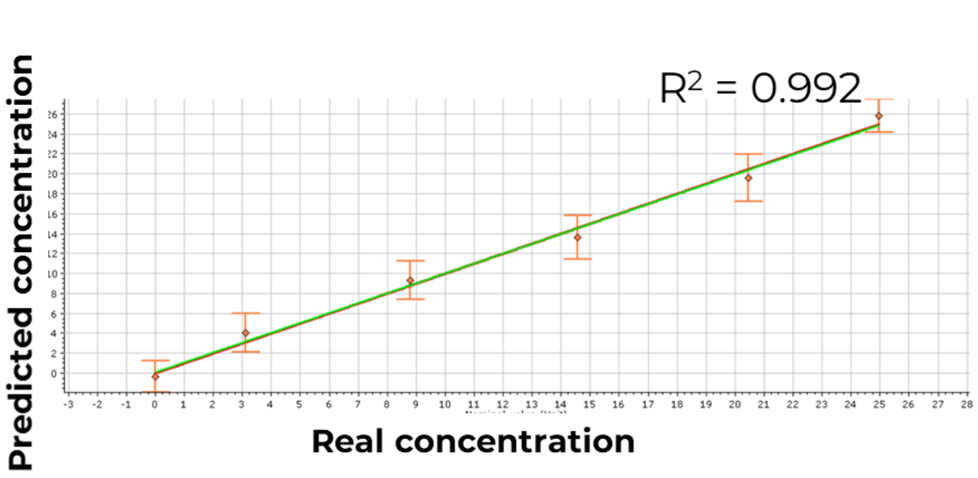


Production and non-destructive quality control via NIR-HSI

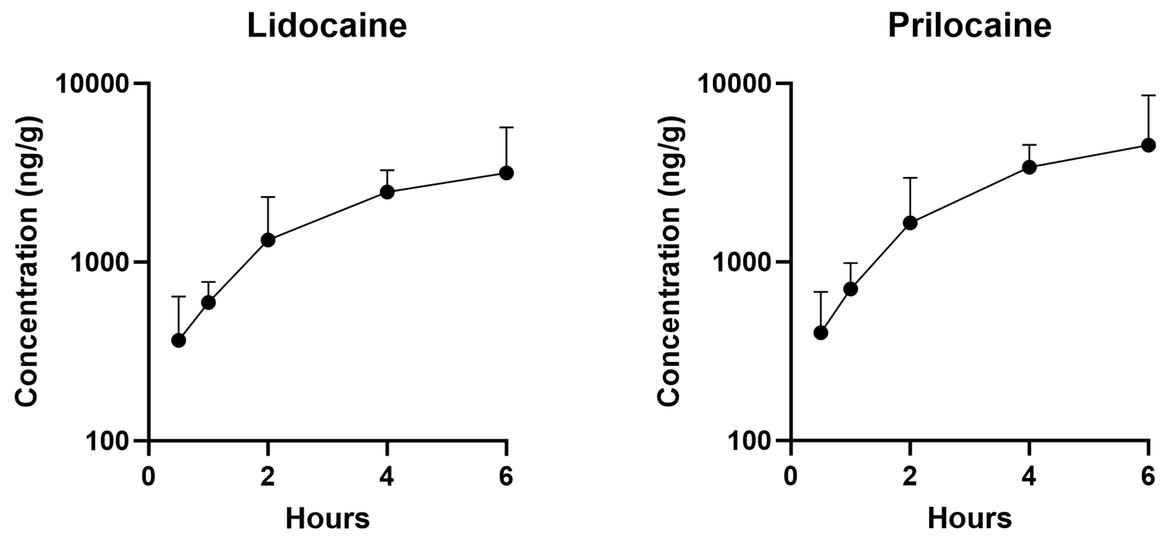
Sample tattoos with varying doses

Results

Tattoos with varying drug loadings (between 10 and 20 mg/cm²) were successfully printed and verified using hyperspectral near-infrared (HS-NIR) analysis and gravimetry. Both lidocaine and prilocaine permeated the epidermis of human skin explants, reaching peak concentrations in the upper and lower dermis after 4 hours. These findings demonstrate that the tattoos are suitable for local anesthesia during medical procedures and effectively deliver the lidocaine:prilocaine mixture to relevant skin layers.



Calibration curve of NIR-HSI model for API quantification



Permeation of lidocaine and prilocaine over time

Conclusion

Our approach outlines a generic workflow for personalized transdermal treatments, allowing non-destructive assessment of quantity and quality—a step toward patient-centered dosage forms. The next steps towards commercialization will be investigated in an i3 – project (*Smart Manufacturing of Biomedical Applications by industrial multi-material Inkjet Processes for improved Health Care*).

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