
SBPMat
B-MRS
SOCIEDADE BRASILEIRA
DE PESQUISA EM MATERIAIS
SALVADOR
XXIII B-MRS Meeting 2025
September 28th to October 2nd
BRICS
Brasil 2025

Fibroin nanofibrils@AuNP nanohybrid modifying 3D-printed microneedles for colorimetric wearable sensors for levodopa

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Portable electronic devices (POC) based on 3D-printed microneedles (MN) enable strategic customization of biofluid monitoring, tracking biomarkers for homeostasis, disease monitoring, and organ function.[1] This work developed a wearable biosensor using 3D-printed hollow MNs (average aspect ratio of 1.55), shaped as hypodermic needles, integrated with nanostructured fibroin nanofibrils (FNF) and AuNP (FNF@AuNP) films. The target analyte was levodopa (L-dopa), the primary intervention for Parkinson's disease (PD). Fibroin nanofibrils from Masuko grinder are a novel material, rarely explored in sensor platforms. FNF of 35.6 ± 16 nm were used in the synthesis of AuNP, which showed typical spherical shape with average diameters of 21 ± 5 nm. Initial trials with FNF@AuNP aqueous suspension and UV-Vis spectroscopy revealed, in the presence of tyrosinase, levodopa detection in a 6–60 µM range, with a 3 µM detection limit and suitable selectivity for pharmaceutical applications. Visual color changes were chosen for transduction to facilitate use by PD patients. Simulated real POC tests showed efficient collection and concentration of interstitial fluid by the MN patch. The FNF@AuNP films cast on the patch's backside exhibited visual color changes upon tyrosinase exposure, tracked using a paper disc for analysis. Digital photographs of reaction media enabled color-change monitoring via image processing and visualization techniques, enhancing system robustness and accuracy. High levels of levodopa (above 50 µM) were detected in simulated interstitial fluid with required selectivity. The proposed sensor advances silk fibroin applications in nanobiotechnology and supports sustainable, accessible, and efficient wearable diagnostics, improving PD patient care.

Acknowledgements
FAPESP (2018/18468-2, 22/05316-5, 23/13428-0, 24/14742-3)

References
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