LIFOMUL 3D - LIgnin FOrmulations for MULtimaterial 3D printing of microneedle electrodes

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Metallised microneedle electrodes have been demonstrated as valid alternative to well-established wet electrodes for electrocardiography- (ECG) and electroencephalography- (EEG) measurements. The advantage of microneedles primarily lies in their drastically reduced skin-electrode impedance, reducing the signal noise ratio. This is particularly relevant for specialty ECG and EEG applications such as long-term monitoring. Since these electrodes are single-use disposable parts, the approach of the LIFOMUL 3D project is to advance additive manufacturing to fabricate microneedle electrodes in an environmentally sustainable and economically viable fashion based on renewable materials. To this end, LIFOMUL 3D is implementing the processing of polymer formulations based on lignin via projection-microstereolithography (PµSL). Lignin is the second-most abundant natural polymer and accumulating as byproduct during cellulose processing. The material development proceeded starting from chemically modifying lignin for light-triggered photopolymerization over 3D printing development accounting for the variety of lignin sources and intrinsic viscosities, molecular weights as well as impurities. The lignin modification was optimized in relation to costs and benefits with possibility of upscaling. The result was a lignin content in photopolymer formulation of up to 15 wt% for unmodified and of up to 30 wt% for modified lignin.

The PµSL system was developed based on a high-resolution light engine. Moreover, the system was designed to permit hybrid printing of two different materials and incorporates a cleaning process of 3D-printed structures before switching from one material to the next one. Microneedles consisting of two different resins were successfully printed with lignin-based microneedles showing a tip diameter of only 6 µm.

The 3D-printer and the lignin-based resins are currently developed toward product maturity. Together, they enable the manufacturing of microstructures for medical applications in an environmentally sustainable way.

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