

Ergonomic 3D-Printed Electrochemical Platform: Design and Functionalization

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Additive manufacturing (AD) is recognized for its transformative approach to fabricating electrochemical platforms. Its ability to combine structural design flexibility with rapid prototyping offers significant advantages for customizable and accessible sensing technologies. Nevertheless, complete systems in which all components are 3D printed and optimized for electrochemical performance remain relatively underdeveloped.

In this work, we manufactured a fully 3D printed electrochemical sensing platform in which the electrodes and an ergonomic measurement cell were fabricated via fused deposition modeling (FDM) (see Figure 1). Carbon black/poly(lactic acid) (CB/PLA) filament was employed for the electrodes, while the cell body was printed from standard PLA. To improve electrochemical performance, all electrodes (working, counter, and reference) underwent a combined activation procedure involving dichloromethane treatment followed by sequential anodic and cathodic polarization. A tailored surface modification strategy was applied to auxiliary electrodes: the reference electrode was coated with electrodeposited silver and AgCl to stabilize its potential, while the counter electrode was modified with platinum particles. It was found that the surface coverage of the modified electrodes was not uniform and the metallic deposits outperformed the distribution of the electrode catalytic sites. Nevertheless, proposed solutions offered a cost-effective replacement for commercial components. The structure and surface properties of the printed elements were examined using complementary techniques, such as voltammetry, chronoamperometry, electrochemical impedance spectroscopy, scanning electron microscopy, optical profilometry, attenuated total reflectance Fourier–transform infrared spectroscopy, laser–induced breakdown spectroscopy, and wetting analysis. System performance was first verified with ferrocenemethanol as a model redox probe and then applied to the determination of paracetamol. The platform achieved a detection limit of 0.38 μM and a quantification limit of 1.26 μM . Successful analysis of pharmaceutical tablets by the standard addition method demonstrated the applicability of the proposed low-cost and fully 3D-printed device for quantitative measurements in complex matrices [1]



Figure 1: Electrochemical cell with incorporated electrodes, fabricated using FDM.

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References

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