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# Development and Characterization of a Microfluidic Immunosensor for Non-Invasive and Continuous Monitoring of Proinflammatory Pathologies: Enhancing Sensitivity and Multifunctionality

**Authors :** Nessrine Jebari, Elisabeth Dufour-Gergam, Mehdi Ammar

**Abstract :** This work outlines the development and characterization of a microfluidic immunosensor, designed for real-time monitoring of proinflammatory pathologies, within the domain of biomedical diagnostics. The key focus of this research is the microfabrication protocol developed in a cleanroom environment, emphasizing the intricate processes employed in the fabrication of this sophisticated biosensor. The principal contribution of this project is grounded in the application of COMSOL Multiphysics for detailed three-dimensional simulations, which are instrumental in the development of a patch-like device designed for non-invasive monitoring of biomarkers in sweat. The device integrates a distinctive combination of magnetofluidic manipulation and capacitive sensing approaches, thereby enhancing the standard in biomarker detection and quantification. A pivotal aspect of our device is its use of biomarker-tagged magnetic nanoparticles (MNPs), significantly enhancing sensitivity and multifunctionality. The immunosensor comprises two main units: the primary unit, featuring an array of serial microcoils for optimal MNP trapping and microfluidic mixing, and the secondary unit, a layered structure with a planar microcoil and two copper electrodes. This configuration forms a capacitor integral to the capacitive sensing capabilities of the device, allowing for precise quantification of biomarker-tagged MNPs. The microfabrication process, executed in a controlled cleanroom environment, involved the precise layering and structuring of microcoils and electrodes, along with the integration of a microfluidic platform. This meticulous process ensures high reproducibility and accuracy, critical for a reliable diagnostic tool. Experimental results exhibit the immunosensor's promoting sensing capabilities, with a sensitivity range of 60% to 75% at 70% MNP occupancy in the detection zone. This performance underscores the device's potential in overcoming the limitations of surface biochemical functionalization, a challenge in conventional biosensors. Beyond monitoring proinflammatory pathologies, the immunosensor's versatility extends to detecting a wide range of pathogens, including bacteria. Its compatibility with complementary screening techniques allows for the identification of multiple biomarkers, enhancing its utility in both clinical and research settings. Conclusion: In conclusion, the development of this microfluidic immunosensor marks a significant result in biomedical engineering and diagnostic technology. The microfabrication process, executed in a cleanroom environment, is crucial to the device's distinctive design and its multifunctional attributes. This technology not only progresses the realm of biomedical diagnostics but also paves the way for further exploration and development within the discipline. Its applications extend from early disease detection to the monitoring of treatment effectiveness.

**Keywords :** COMSOL multiphysics 3D simulation, microfluidic immunosensor, magnetofluidic manipulation, magnetic nanoparticle trapping, laboratory-on-patch technology
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