

Integration of Preconcentration Chip with the Field Effect Transistor (FET) Biosensor for biomarker detection

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This study presents a microfluidic platform for the detection of Serum Amyloid A1 (SAA1), a key biomarker of Acute Respiratory Distress Syndrome (ARDS). As SAA1 appears early in disease progression at extremely low concentrations, enhancing detection sensitivity and lowering the limit of detection (LOD) are critical for timely diagnosis. To visualize the preconcentration process, calcein was employed as a fluorescent tracer. An electric field applied to bipolar electrodes induced Faradaic reactions, generating ion concentration gradients and electroosmotic flow, which drove charged molecules to accumulate within designated regions. The microfluidic chip was fabricated by producing SU-8 molds, casting polydimethylsiloxane (PDMS) channels, and integrating gold electrodes and signal lines onto an acrylic substrate. The PDMS layer was bonded to the substrate and connected to a printed circuit board. A field-effect transistor (FET)-based biosensor was incorporated for electrical signal readout, enabling a compact device with both preconcentration and detection capabilities. Preconcentration efficiency and zone displacement were first characterized under varying voltages. Anti-SAA1 antibodies were then immobilized on gold electrodes to create a specific biosensing interface for detecting antigen–antibody interactions. Finally, preconcentration and biosensing were integrated into a single chip to evaluate improvements in detecting ultra-low SAA1 concentrations. The results demonstrated strong preconcentration performance and sensitive electrical detection, highlighting the platform's potential for early ARDS screening and analysis of low-abundance biomarkers.

Keywords: bipolar electrode preconcentration, Faradaic ion concentration polarization, transistor-based biosensor, limit of detection, biomarker detection.

References

- [1] Pin-Hsuan Chen, Chih-Cheng Huang, Chia-Che Wu, Po-Hsuan Chen, Adarsh Tripathi, Yu-Lin Wang, *Sensors and Actuators B: Chemical*, **357**, 131415 (2022)