Microfluidic Biosensor for Infection & Chemotherapy

Degree programme: Master of Science in Engineering
Specialisation: Medical Engineering
Thesis advisor: Prof. Dr. Cédric Bessire
Expert: Prof. Dr. Sandro Carrara (EPFL)

Electrochemical sensors and optical Lateral Flow-Immuno Assays (LFIAs) were integrated into microfluidic platforms to enhance point-of-care testing, focusing on improving sensitivity and extending the detection range of Etoposide (ETO), Methotrexate (MTX), and C-reactive protein (CRP). The microfluidic integration offers a significant advancement by enabling precise control over fluid dynamics, thereby enhancing biomarker quantification.

CRP Fluorescence Detection

This study explores a method for measuring CRP concentration using CRP antibodies conjugated with green fluorescent labels. In Fig. 1, the fluorescent label-based method significantly extends the CRP detection range from 0 to 70 µg/ml, improving its versatility across diverse clinical scenarios including not only viral and bacterial infections exhibiting CRP levels around 20 µg/ml but also below 5 µg/ml in chronic diseases such as cardiovascular conditions.

Integration into a microfluidic design for in-vitro blood diagnostics enables precise control over the timing and mixing of CRP with fluorescently labeled antibodies. This level of control is unattainable in conventional LFIAs. This novel approach reduces the nitrocellulose pad to the test line area, thereby minimizing non-specific binding of conjugated antibodies to unwanted sites without requiring blocking reagents and still enables a one-step test without a rinsing solution as commonly used in LFIAs.

ETO and MTX Electrochemical Detection

ETO and MTX electrochemical interaction was investigated using single electrochemical sensors in anticancer chemotherapies. The electrochemical oxidation behaviors of ETO and MTX were examined, confirming that multiple drugs can be detected simultaneously on a single bare carbon electrode. However, it was observed that the two compounds exhibit electrochemical oxidative cross-reactivity, causing interference. Fig. 2 shows the sensor integration into a microfluidic chip that enables the reduction of blood volume for in-vitro diagnostics by 80%, while simultaneously enhancing specifically ETO and MTX signal detection in the complex blood plasma matrix.

Amirmahdi Tavakolidakhrabadi
taa4@bfh.ch

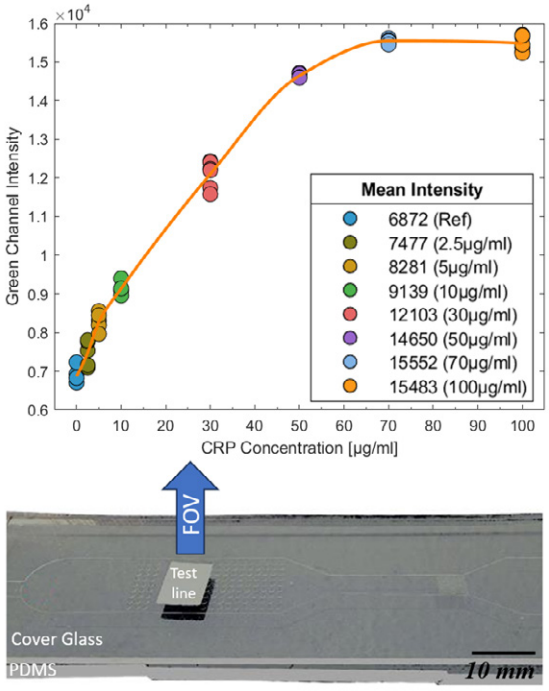

Fig. 1. Microfluidic chip for CRP fluorescent detection with 16-bit optical transfer characteristics.

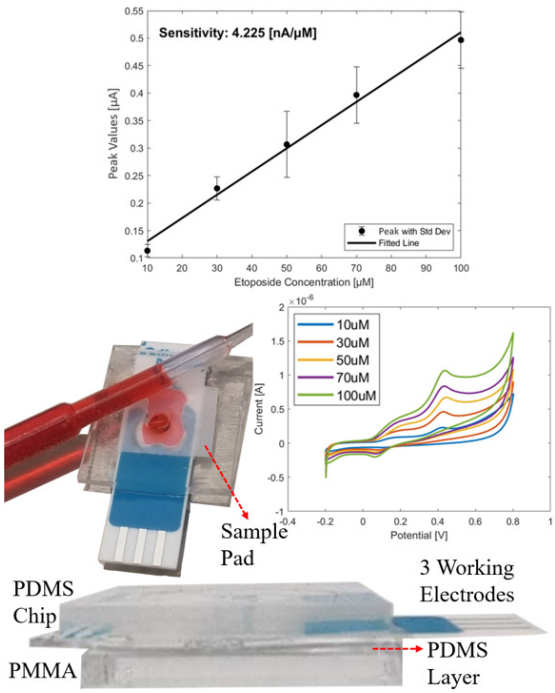

Fig. 2. Microfluidic chip for simultaneous electrochemical detection of ETO and MTX with the voltammetric sweep.