On the integration of printed electronics in fluid cartridges and lateral flow devices for point-of-care

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The use of non-invasive body fluid testing, such as the analysis of blood and urine, can greatly improve clinical decision making in a plethora of situations. It can support clinical triage in low resource settings that typically relies on fever and blood pressure measurements and questionnaires (indirect) as well as semi-quantitative point-of-care (POC) tests (direct). Both, indirect and direct assessments can be prone to misinterpretation. POC devices providing on the one hand fully quantitative measurements and on the other hand improved sensitivity can help closing this gap. We present two strategies enabling the use of printed electronics in POC devices for multiplexed and highly sensitive diagnostics.

The fist example entails an electrochemical sensor array for multiplexed urinalysis. A point of care cartridge (Fig. 1A) with printed sensors allows the accurate quantification of urine analytes at levels that are not detectable with conventionally used cheap solutions, such as the urine dip stick, thereby providing relevant data for improved medical decision making. The array comprises sensors for glucose, sodium, and pH and the digital data allows using smart algorithms for data interpretation. Assays were developed and applied on low-cost screen-printed sensors integrated in a fluidic chip cartridge equipped with storage pouches containing the necessary solutions for the reference electrode and calibration solutions for the sensors. Electrochemical measurements were run in parallel to provide results in 3-4 minutes, including calibration. Validation measurements were carried out with 20 urine samples from healthy donors and showed good correlation (r=0.88 to 0.98) with conventional laboratory analysis results.

The second example illustrates how a combination of a conventional lateral flow immunoassay (LFA) and printed electrochemical sensors can realize a digital POC device with improved sensitivity (Fig. 1B). The developed solution facilitates protein quantification in human serum at concentration levels up to 100-fold lower than LFAs and thus competes with ELISA kits. Hereby, a LFA strip is integrated into a holder containing screen-printed electrodes. The assay readout is based on enzymatic signal amplification in conjunction with open circuit potentiometry or chronoamperometry. The assay was optimized for the detection of placental growth factor, which is crucial to be quantified at picomolar concentrations in clinical risk assessment for preeclampsia. Such concentrations are far out of reach for conventional LFAs and thus a fundamental advancement for all disease diagnostics requiring highly sensitive protein detection in complex body fluids.

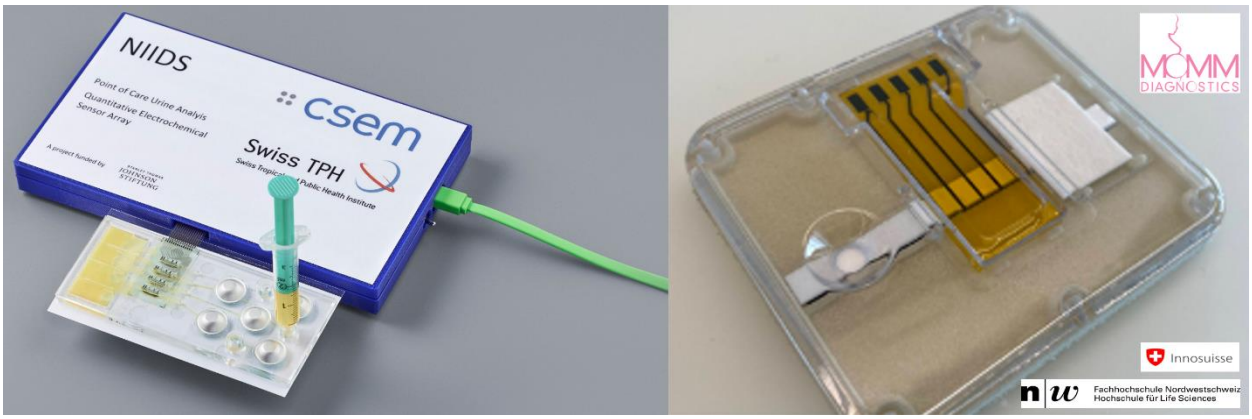

Figure 1: (A) Fluidic cartridge with a printed sensor-based sensor array for multiplexed urinalysis. The cartridge is linked to a remote and USB connected readout module. (B) A combination of a lateral flow immunoassay strip and screen-printed electrochemical sensors allows for highly sensitive protein quantification in human serum for the disease risk assessment of preeclampsia.