Development of Electroanalytical Platforms for Preventative care and Forensics using Paper, Microfluidics, and Spectroscopy

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High-technology was critical to push progress in diagnostics, monitoring of patients, drug discovery and biological and chemical analysis. Due to the cost, maintenance and infrastructure associated with high-end instrumentation, and thus preventing a global access to those tools, the past decades also saw a large effort towards low-cost diagnostics tools for point-of-care (POC). Paper is available everywhere and, although we use it less and less at home or in the office with the all-electronic era, paper can be an interesting substrate for scientists. Light-weight, versatile, flexible and globally available, paper is a good candidate for portable, low-cost and simple platforms that permit efficient and convenient analysis at the POC.

We are developing a potassium sensing platform based on voltammetric solid-state ion-sensing. The quantification of potassium and other electrolytes in blood is useful for health assessment in preventive care, as well as other analytical applications such as soil or water testing, and forensics. This analytical method has a high potential for miniaturization: adapting the ion-sensing assay to nano-electrodes could permit ion quantification at specific locations unreachable with standard ion selective electrodes, such as the intercellular space in a tissue. We are also working on paper-based devices for easy in-field collection and detection of chlorate, an inorganic oxidizer used in improvised explosive devices (IEDs). The presence of chlorate in pyrotechnic products, pesticides, and weed killers make those sensors relevant for applications in forensics and environmental monitoring. Paper can also support culture of bacteria. By combining culture capabilities and electrochemistry, we are generating electrochemical paper-based devices for the culture and detection of bacteria in resource-limited settings.

Fast and convenient methods to quantify bacteria with high sensitivity (<10-100 CFU) already exist, however, most methods relies on exposure to large amount of sample, long incubation time, culture, amplification, sophisticated detection devices or a combination of those to bring the bacteria level in the instrumentation detectable range. We are designing a reverse electrochemiluminescent (ECL) assay, where bacteria, confined in droplets, will be detected through a decrease of the electrochemically generated light. The small confinement vessels allow for an apparent higher concentration as well as greater changes in the sensor response.

In summary, our interdisciplinary research group combine electrochemistry with other area of chemistry-physics, materials and biology to generate innovative bioanalytical and forensic tools.