Electrochemically Actuated, Screen Printed, Capillarity-Driven Microsystems for Food Safety and Clinical Analysis

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Lab-on-Chip (LOC) concepts are usually realized as microsystems fabricated by microfabrication technologies of varying degrees of complexity and operated by control equipment that commonly require external power sources, fluid movement devices, and detection systems. Investment in purpose-built manufacturing lines, for micron or sub-micron featured microsystems and sophisticated control apparatus is justified for high throughput analytical tasks based on limited-volume samples.

Most analytical needs in food safety and decentralized diagnostics/theranostics are not limited by the available sample volume and are not high throughput in nature; rather it is cost and ease of use that eventually decide their large scale adoption. A convenient alternative for the realization of such application-oriented LOC concepts is to manufacture simple, basic microsystems by 3-D screen printing. Such elemental microsystems can be operated almost autonomously: fluid movement can be achieved through capillary action, and both fluidic control and detection by electrochemistry. Screen printing manufacturing requires a simple and relatively low cost production line and provides the flexibility to incorporate different materials in the 3-D design accommodating both structural and actuation or detection elements. We demonstrate that basic unit operations such as dissolution, separation, mixing, reaction, flow manipulation and detection can be satisfactorily realized and controlled for most detection applications.

We applied such simple architectures in integrated devices that can detect pathogens in food and activated sludge. In a particular product developed, *Salmonella* could be detected in poultry meat extracts with limit of detection of 10-20 CFUs within 15 hours of sampling while 100 CFU detection limits can be achieved in less than 2 hours.

When proteins need to be detected by immunochemical methods in lateral flow-type devices rendered by the 3-D screen printing method, we demonstrate that flow control is crucial for signal development and successful immunorecognition. We provide such flow control with electrochemically activated stop/go printed microvalves that modulate the hydrophilicity of the device walls. We thus achieve successful detection of β-lactoglobulin (a potential food allergen) or HCG (a pregnancy indicator).

We therefore present a simple to manufacture, generic. low cost, and easy to use technology platform that can tackle a variety of analytical problems.

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