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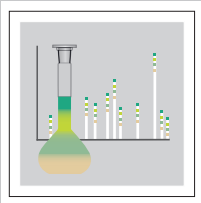

Highlights of Analytical Sciences in Switzerland

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Inkjet Printing: The Future of Disposable Electrochemical Sensors?

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The global demand for disposable, portable, and miniaturized electrochemical sensors has driven printing-based manufacturing techniques for decades. The potential for low unit costs on a large-scale has been a key driver behind some of the most successful innovations in point-of-care sensor technology, such as the electrochemical sensing of blood glucose. However, other potential fields, such as in-field bacterial detection or roadside drug testing, are still underexplored. While screen printing has been the standard technique for years, modern analytical challenges require high-performance, scarce, and expensive sensing materials (*e.g.* Au, Pt, graphene). This makes screen printing less sustainable due to high material consumption and limited flexibility in pattern design and material choice.

Therefore, digital and mask-less deposition techniques, such as drop-on-demand inkjet printing (IJP), are increasingly replacing traditional mask-based methods. Picolitre-sized droplets (*e.g.* of graphene-based inks) are jetted on-demand at kHz frequencies by piezoelectric actuation of individually addressable nozzles. Combined with precise positioners, high accuracy is achieved, with optimally zero material waste in a reasonably short time. Subsequent thermal processing removes ink solvents and stabilizers, creating conductive electrodes. However, establishing defined printing and heating protocols is challenging to ensure consistent sensor performance and low sensor-to-sensor variation.

Careful optimization of our printing parameters and post-print heating protocols enabled the large-scale fabrication of graphene-based electrodes with controllable and switchable analyte sensitivity. Analytical performance was tested for key antioxidants (*e.g.* uric acid), bacterial infection markers (*e.g.* resazurin) and cannabinol-sensitive redox indicators. By applying defined heating protocols in vacuum and air the same sensor can reversibly switch between a quantitative global signal and qualitative compound identification using the same measurement technique. Combined with superior sensitivity and selectivity over leading-edge carbon-based electrodes, such as glassy carbon, IJP sensors are likely to dominate future single-use applications in electroanalysis.

The optimization of inkjet printing and post-processing enables cost-effective production of high-performance electrochemical sensors with seamless scalability from prototypes to industrial manufacturing.

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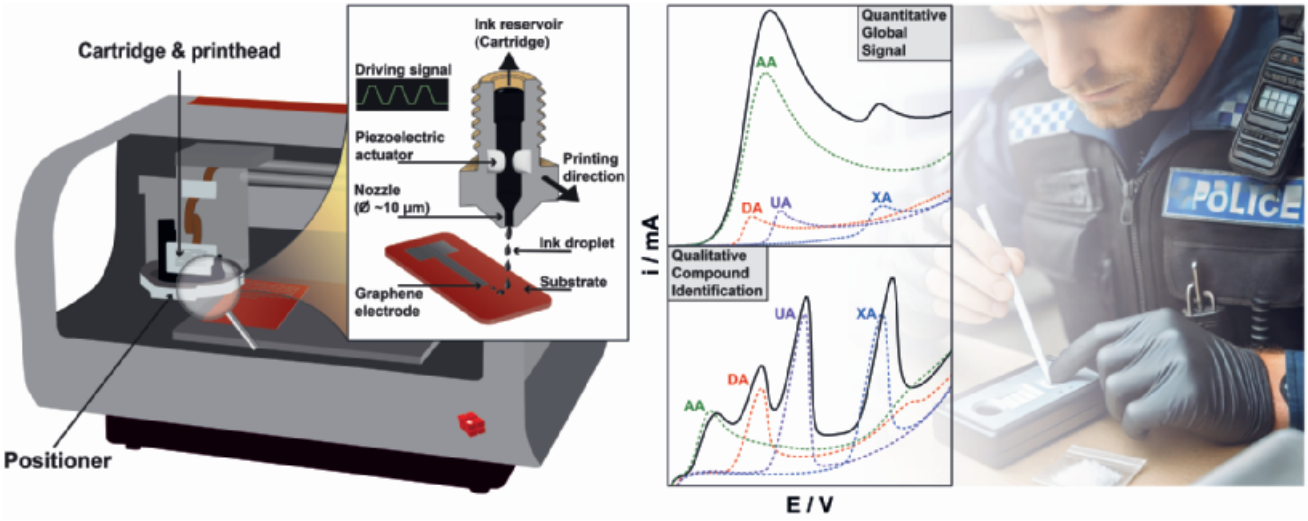

Fig. 1. Schematic illustration of a lab-based inkjet printer showing cartridge, printhead and positioner (left). The magnified inset illustrates the printing process to fabricate high-performance and low-cost graphene electrodes. Defined post-print heating protocols allow reversible switching between a quantitative global signal (*e.g.* for antioxidant potential) and qualitative compound identification using linear sweep voltammetry (center). This provides a versatile tool to advance the use of IJP electrodes in new electroanalytic fields, such as roadside drug testing (right). (UA: uric acid, AA: ascorbic acid, DA: dopamine, XA: xanthine).

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