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Development of a printed paper-based origami electrochemical sensor for the detection of heavy metals in water

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Abstract

This paper presents a printed paper-based origami electrochemical sensor for the detection of heavy metals in water. Heavy metal contamination in water has significant health risks and environmental complications. The detection is typically performed in a laboratory with lengthy result turnaround times. Paper-based detection provides an ideal platform on which to develop solutions to address these challenges, particularly for under-resourced settings, as it is inexpensive, disposable, and can be deployed at the point-of-need to provide rapid results for environmental and disease control. The paper-based origami device was successfully fabricated using wax printing techniques to print the hydrophobic barriers and screen printing techniques to print the three-electrode electrochemical sensor on chromatography paper. An origami design enables enhanced fluidic control to be achieved, as the porous paper structure facilitates flow, and filters out all potential debris in the sample before reaching the sensor. Vertical as well as horizontal fluidic flow is realized using the folding origami design, allowing for better filtering of debris. The results demonstrate the filtering of debris from dirty water and the detection of parts per billion levels of lead and cadmium ions in buffer solution on a single two-dimensional electrochemical sensor printed on chromatography paper. The detection results of lead and cadmium ions on chromatography paper were compared to commercially available screen-printed ceramic electrochemical sensors. The proposed paper-based origami electrochemical sensor device with fluidic handling capabilities demonstrates a simple, low-cost, disposable paper device suitable for the detection of heavy metals in water samples.