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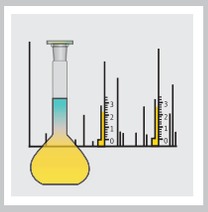

Highlights of Analytical Sciences in Switzerland

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Equipment-free Detection of K^+ on Paper

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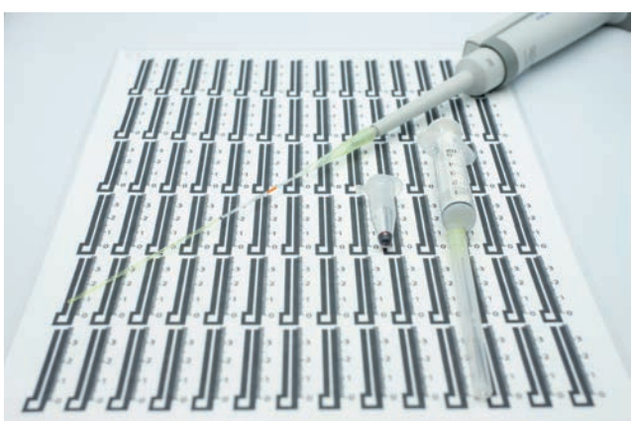
Keywords: Equipment-free analysis · Ion-selective membrane · Point-of-care diagnosis · Serum sample analysis

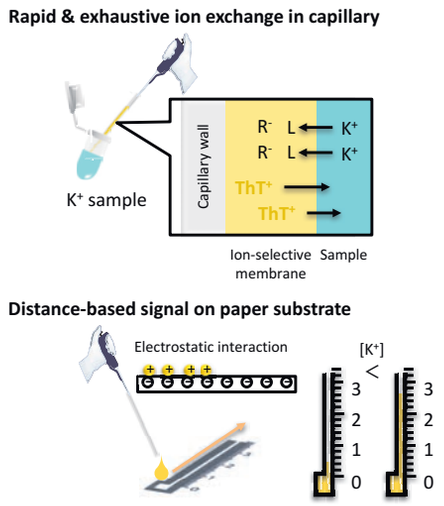
Microfluidic paper-based analytical devices (μPAD) have been introduced as simpler variants of lab-on-a-chip (LOC) devices, aiming at point-of-care (POC) diagnostics of various analytes. While colorimetric detection is a promising signal output principle, it has difficulty meeting the requirements of the World Health Organization and associated feasibility of commercialization.

This work describes μPADs for the equipment-free detection of K^+ in a 10 μL serum sample where K^+ concentration is translated to a distance-based signal. This goal is achieved by separating recognition and detection steps. The recognition part uses an ion-selective film solvent-cast into a glass capillary. This coating contains a charged dye, thioflavin T (ThT^+), along with the K^+ ionophore valinomycin. Once a 10 μL sample volume is aspirated into the capillary by a commercial pipette, K^+ in the sample is allowed to be exhaustively exchanged with ThT^+, thereby releasing a quantity of ThT^+ that reflects the original amount of K^+. To allow for a distance-based detection, this ThT^+ is discharged into a paper channel defined by hydrophobic wax barriers. As the sample flows, ThT^+ binds electrostatically to anionic functionalities of the cellulose substrate, which is further enhanced by a polyanionic coating. Higher amounts of K^+ translate into a higher quantity of ThT^+, in turn resulting in an increased distance of the perceivable color band on the μPAD.

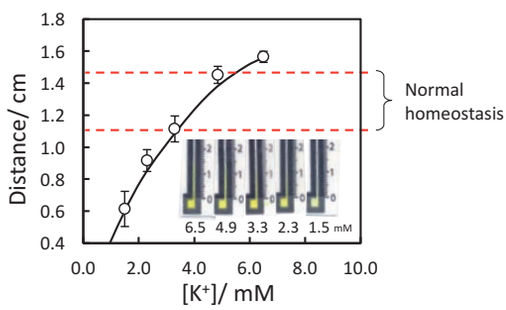
The exhaustive depletion of K^+ makes it possible to detect K^+ with high sensitivity in a narrow concentration range, suitable for serum diagnostics (3.5~5 mM). In comparison with traditional ion optodes, this readout principle does not depend on the sample pH and gives a more sensitive response while maintaining a high selectivity. The distance-based readout is more robust than colorimetric detection, which is notoriously difficult to quantify, and does not require any readout equipment. **This device principle may pave the way for the practical realization of μPADs for the detection of ions.**



Apply a drop of serum through a special capillary into a paper channel and get the result!



Schematic illustration of the distance-based analysis of potassium ions with an ion-selective capillary film (top) that exhaustively exchanges potassium ions for the cationic dye ThT^+. This dye is in turn detected on paper *via* electrostatic interactions, giving a distance-based visual readout (bottom). Adapted with permission from Y. Soda *et al*., *ACS Sensors* **2019**, *4*, 670. Copyright (2019) American Chemical Society.



Result of distance-based analysis of K^+ in pooled serum samples. Adapted with permission from Y. Soda *et al*., *ACS Sensors* **2019**, *4*, 670. Copyright (2019) American Chemical Society.

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