Equipment-free Detection of K+ on Paper

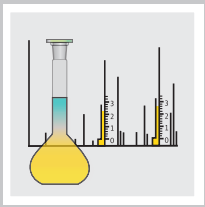
Soda, Yoshiki; Citterio, Daniel; Bakker, Eric

How to cite

SODA, Yoshiki, CITTERIO, Daniel, BAKKER, Eric. Equipment-free Detection of K+ on Paper. In: Chimia, 2019, vol. 73, n° 11, p. 944. doi: 10.2533/chimia.2019.944

This publication URL: https://archive-ouverte.unige.ch/unige:142028
Publication DOI: 10.2533/chimia.2019.944

doi:10.2533/chimia.2019.944 Chimia 73 (2019) 944



Highlights of Analytical Sciences in Switzerland

Division of Analytical Sciences

A Division of the Swiss Chemical Society

Equipment-free Detection of K^+ on Paper

Yoshiki Soda[a], Daniel Citterio*[b], and Eric Bakker*[a]

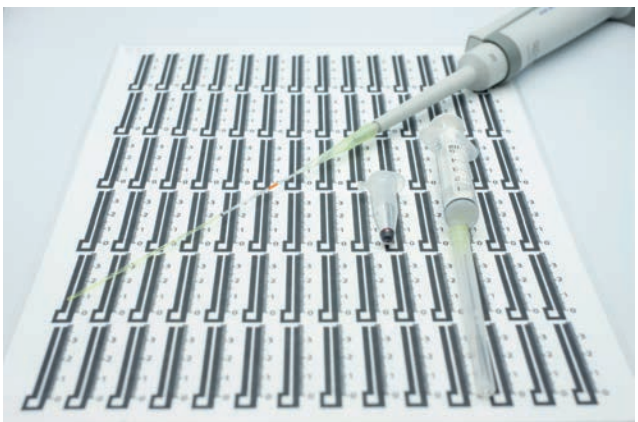
*Correspondence: Prof. Dr. E. Bakker[a], E-mail: Eric.Bakker@unige.ch;
Prof. Dr. D. Citterio[b], E-mail: citterio@applc.keio.ac.jp
[a]Department of Inorganic and Analytical Chemistry, University of Geneva, Quai Ernest-Ansermet 30, CH-1211Geneva, [b]Department of Applied Chemistry, Keio University, 3-14-1 Hiyoshi, Kohoku-ku, 223-8522 Yokohama, Japan,

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

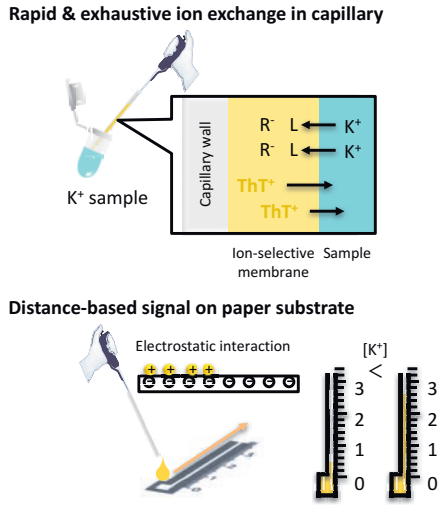
Microfluidic paper-based analytical devices (μPAD) have been introduced as simpler variants of lab-on-a-chip (LOC) devices, aiming at point-of-care (POC) diagnostics of various analytes. While colorimetric detection is a promising signal output principle, it has difficulty meeting the requirements of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

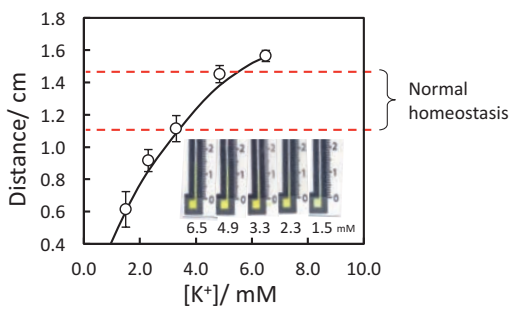
The exhaustive depletion of K^+ makes it possible to detect K^+ with high sensitivity in a narrow concentration range, suitable for serum diagnostics (3.5~5 mM). In comparison with traditional ion optodes, this readout principle does not depend on the sample pH and gives a more sensitive response while 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.

Received: September 9, 2019

References

Y. Soda, D. Citterio, E. Bakker, *ACS Sensors* **2019**, *4*, 670.
B. H. Weigl, O. S. Wolfbeis, *Anal. Chem.* **1994**, *66*, 3323.
X. Xie, J. Zhai, E. Bakker, *Anal. Chem.* **2014**, *86*, 2853.

Can you show us your analytical highlight?
Please contact: Dr. Veronika R. Meyer, Unterstrasse 58, CH-9000 St. Gallen
Tel.: +41 71 222 16 81, E-mail: VRMeyer@bluewin.ch