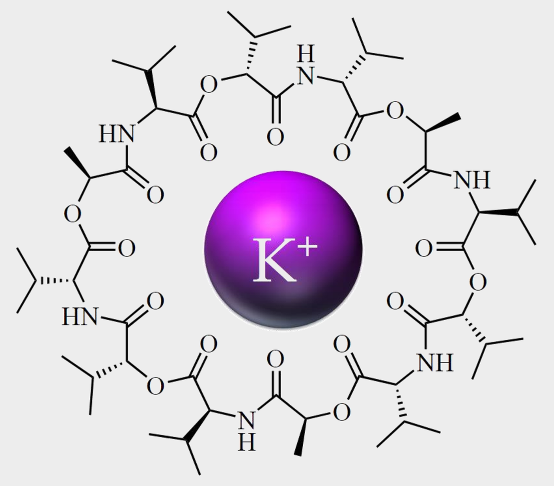
Evaluation of zeolite-modified sensors for monitoring environmentally important species using custom-made Raspberry Pi-based digital colorimeter

Erjona Mulaj[1,2], Vullnet Veseli[1,2], Vladimir Zholobenko[2], Albana Veseli[1], Salma Bertata[2], Ernesto Saiz [2], Aleksandar Radu[2].

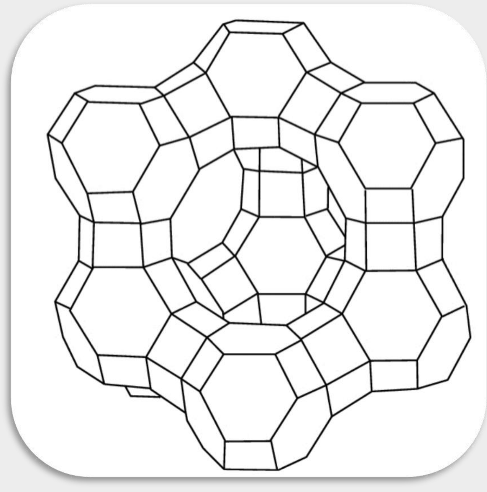
[1]University of Prishtina Hasan Prishtina, Prishtinë, Kosovo,
[2]Keele University, United Kingdom ST5 5BG.
erjona.mulaj1@student.uni-pr.edu

Introduction

Demonstrated here is the utility of PiSENS for determining K^+ in soil using optodes selective for this ion and a custom-made Raspberry Pi based colourimeter. Polymer membrane-based optodes offer excellent possibility to be combined with digital colourimeters due to their well-understood response mechanisms and analytical characteristics. They change their colour relative to the concentration of analyte species in the sample solution which can be monitored using inexpensive computer, capable of analysing colour intensity, signal processing and data transmission.



Valinomycin



NaX

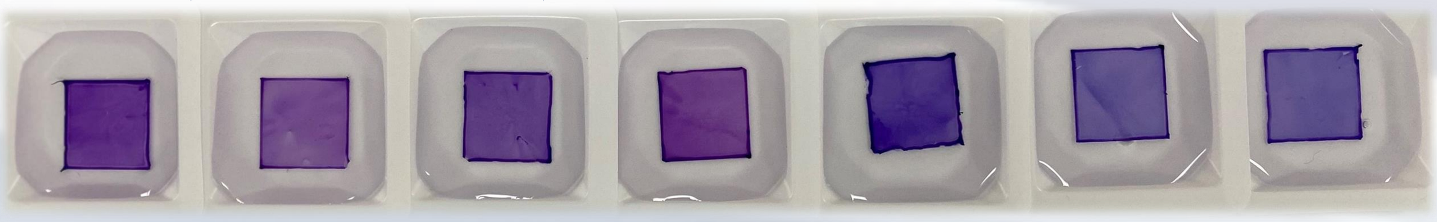
Experimental

Classical optode preparation:

The K^+-selective optode membranes consists of:

- chromoionophore II (ETH 2439),
- ion exchanger KTpClPB,
- potassium ionophore I (valinomycin),
- PVC and DOS.

the components were dissolved in 1 mL of THF. Using an in-house spin-coating device (3,500 rpm), aliquot (~60μL) of the membranes was cast onto cover glass pieces (18mm x18mm).

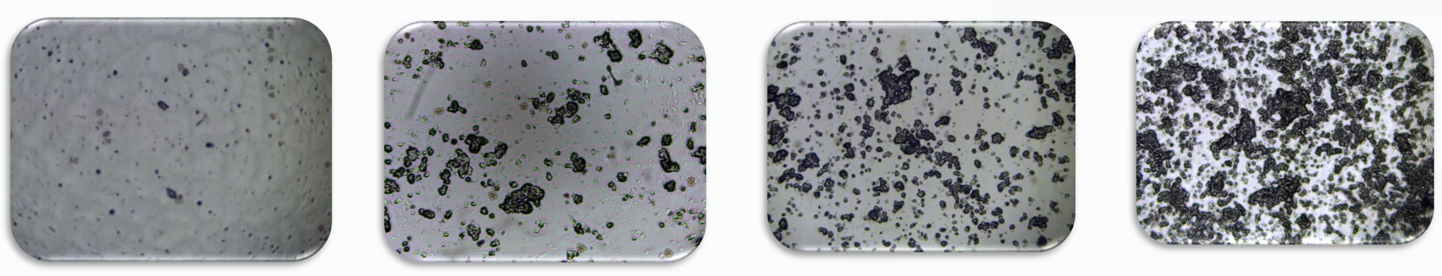


K^+ - selective optode is based on the following equilibrium:

$$K^+_{aq} + HC^+_{org} + L_{org} \rightarrow H^+_{aq} + KL^+_{org} + C_{org}$$

Zeolite-modified optode:

While the other components remained the same, zeolites have been utilised instead of commonly used ion exchanger for optodes, due to their properties as ion exchangers. In our preliminary research, several sensors with different wt.% of NaX zeolite have been made.



1% NaX 5% NaX 10% NaX 20% NaX

Fig.1. Optical images of ZMO with different wt.% NaX in optodes with 50x optical magnification.

Results and discussion

Calibration of PiSENS was performed by using fully protonated and fully deprotonated optodes as boundary conditions required by the code.

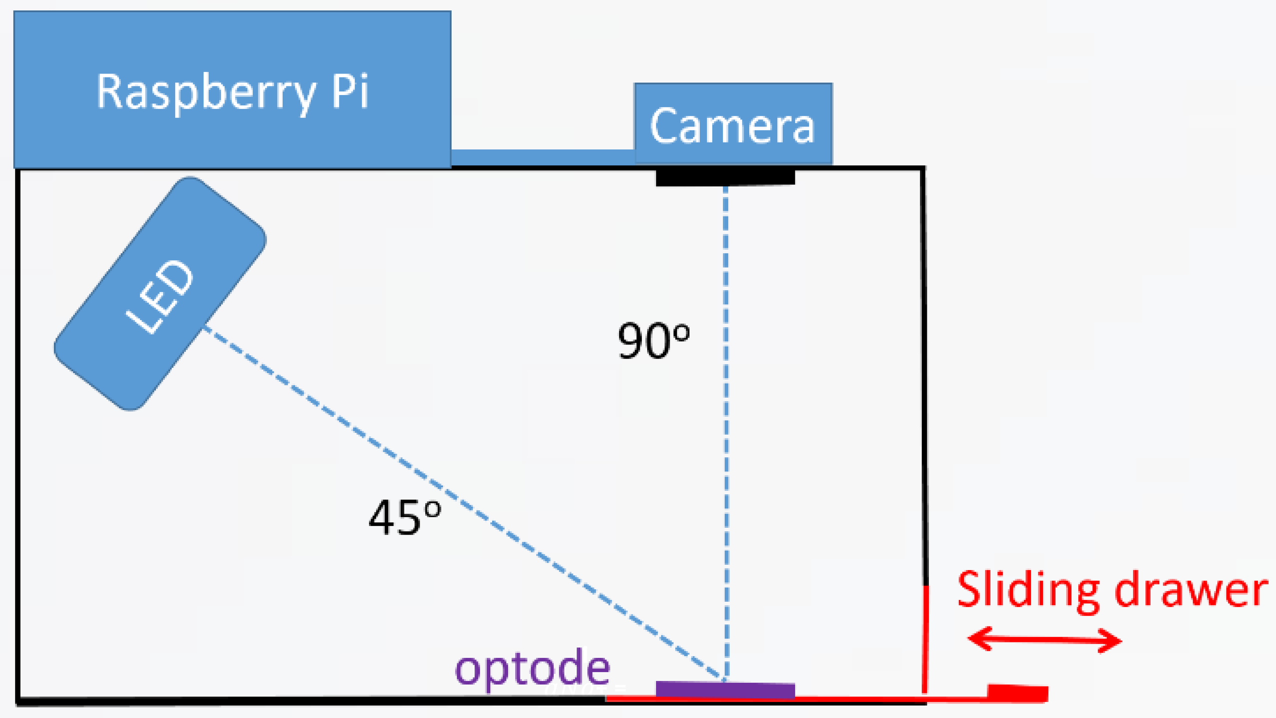


Fig.2. The optode analyser, PiSENS, consists of a 3D printed box with a removable lid containing an optode holder.

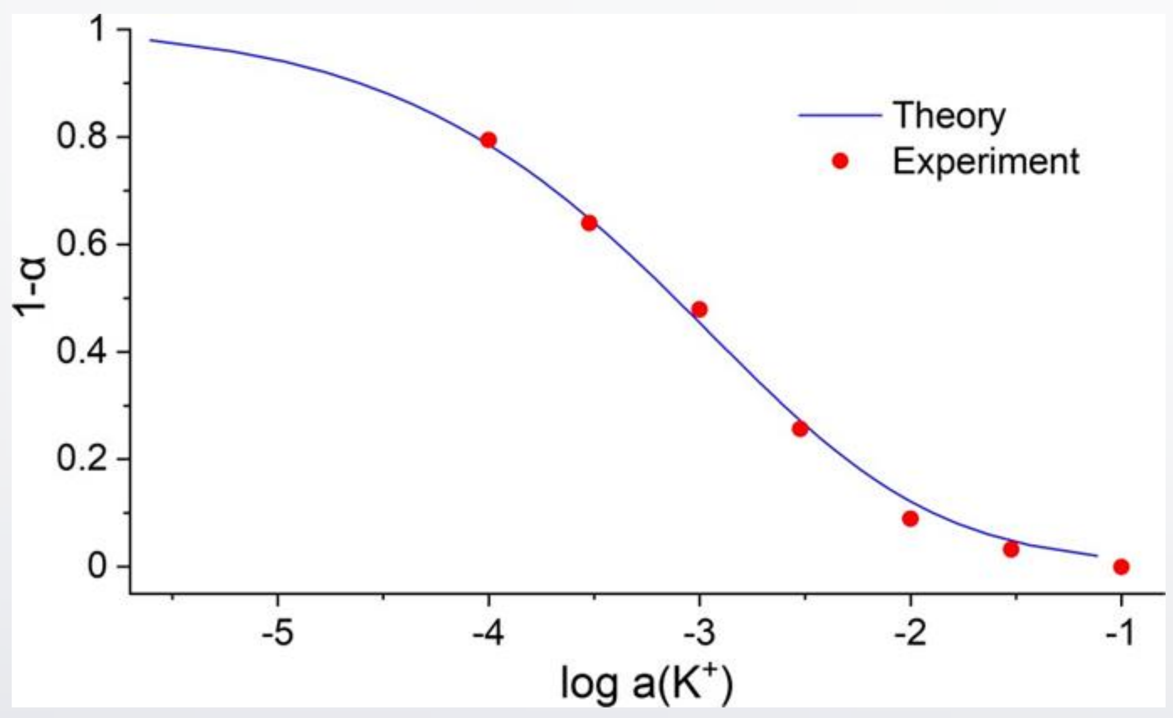


Fig.3. Calibration curve of K^+ in water samples, α is dissociation constant.

Conclusion

- Inexpensive, portable and easy-to-use digital colourimeter for detection of K^+ in soil samples.
- It shows potential to significantly improve the spatio-temporal frequency of analysis especially in rural and remote communities where access to expensive and complex instrumentation is limited.
- In our preliminary research, the idea of replacing the common ion exchanger with zeolites did not produce the desired results.
- However, improvements in sensor design and composition should be made to achieve statistically significant results in the future.

Selected references

❖E.Saiz, S.Espinoza Torres, V.Aleksic, G.Picasso M. O'Brien, A.Radu. Analytical method. In peer review.
❖P.Buhlmann, E.Pretsch, E.Bakker. Chem. Rev. 1998, 98, 1593-1687.