Paper-based organic electrochemical transistor array for multi-analyte detection

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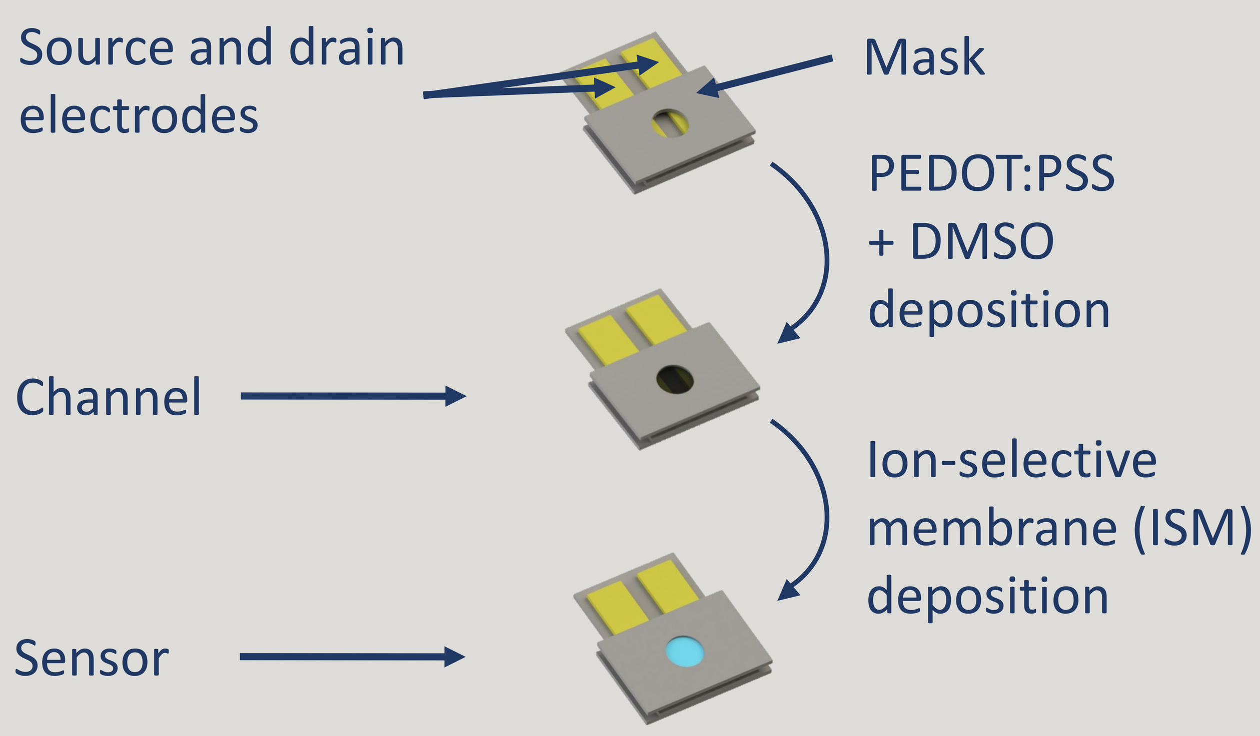
INTRODUCTION

In recent years, organic electrochemical transistors (OECTs) using poly-(3,4-ethylenedioxythiophene) polystyrene sulfonate (PEDOT:PSS), a p-type organic semiconductor polymer, have emerged as a promising alternative due to their high-amplification capacities, robust analytical performance and versatility.[1,2] The present work proposes a compact multi-analyte transistor array with outstanding analytical performance. Ion-selective organic electrochemical transistors (IS-OECTs) were developed by combining the thick-film technology with the optimum ion-selective membrane.[3] The application of multivariate calibration models enhances the analytical performance, allowing the detection and quantification of ions of interest in complex matrices with interfering potentials.[4] A single gate for three transistors enables the miniaturization of the set-up.

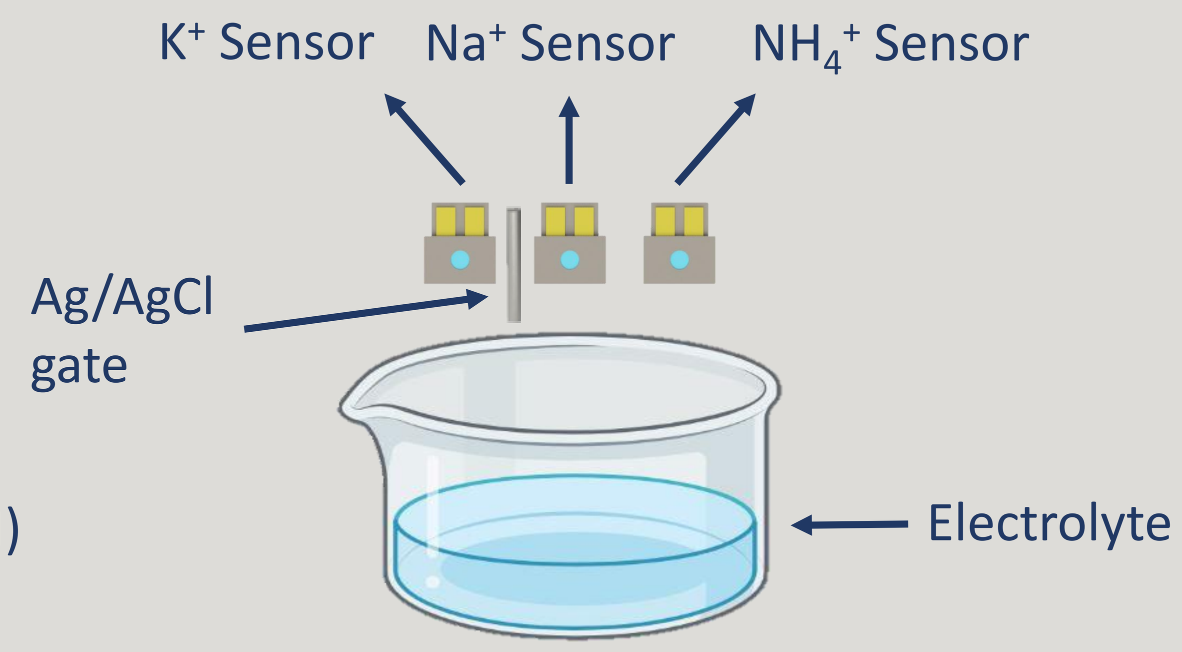
EXPERIMENTAL WORK

1. Sensor construction



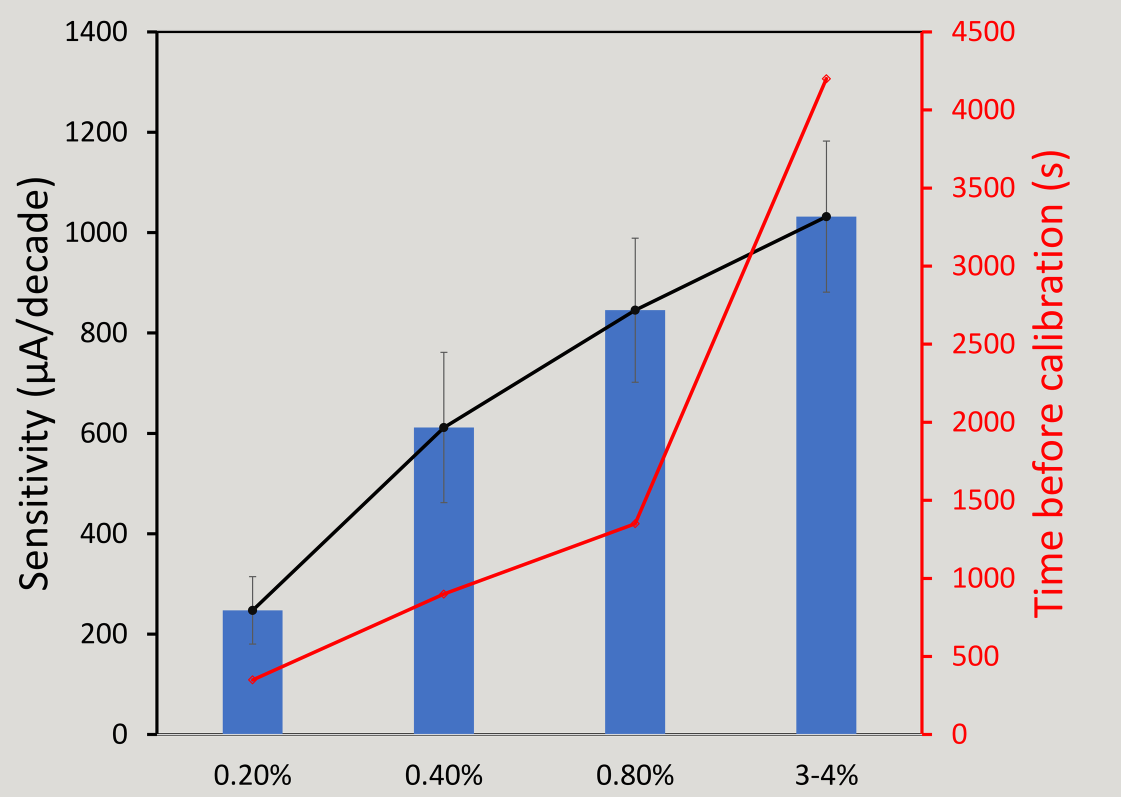
- Optimal methodology for the creation of paper-based sensors.

2. Schematic of the measurement cell



- Compact array of transistors in a potentiometric cell.

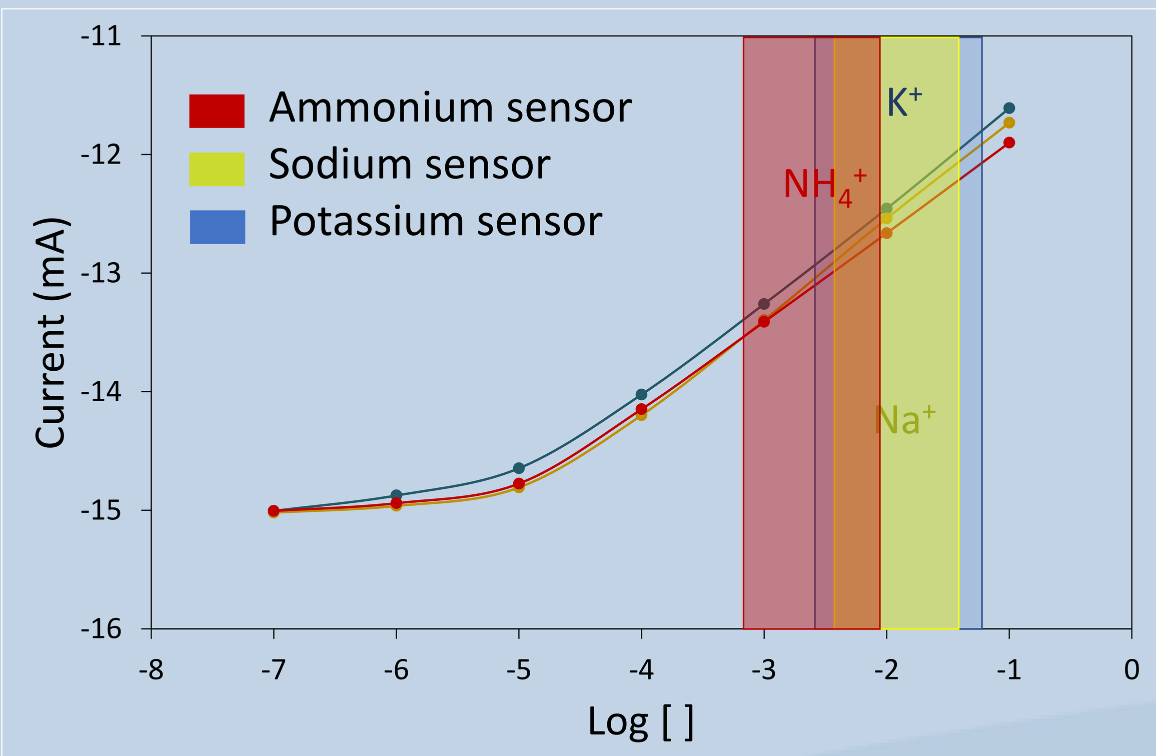
3. Analytical performance



- The increase in concentration of PEDOT produces an improvement in the analytical performance of the sensor in terms of sensitivity.
- DMSO reduce the time before calibration and the variability between sensors.

RESULTS AND DISCUSSION

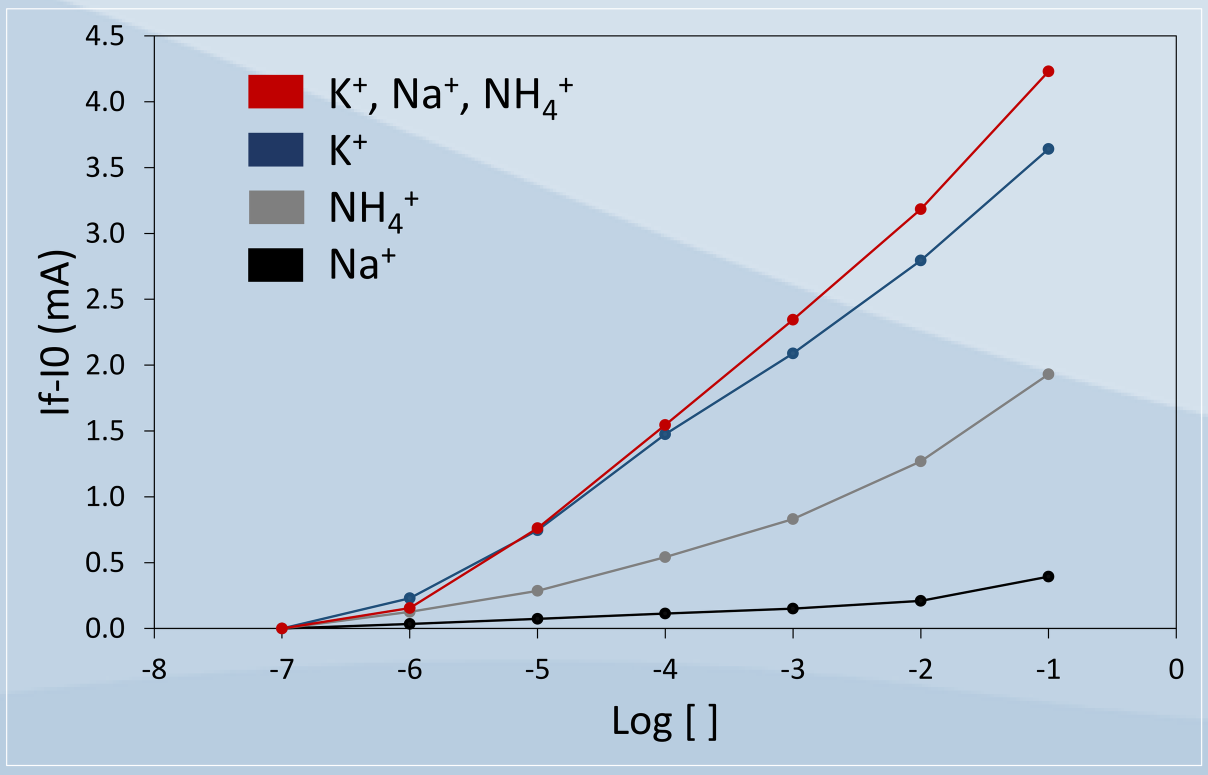
4. Range of interest in human saliva



- All three sensors are linear in the range of interest.

Analyte	Range of interest (mM)
NH_4^+	0.8 – 12.3
Na^+	4.0 – 37.0
K^+	2.6 – 51.2

5. Potassium sensor selectivity



- Data processing through chemometrics is required for selective detection and quantification.

6. Figures of merit of multivariate model

Analyte	RMSEC	Calibration Bias	R^2 (Cal, CV)	RMSEP	Prediction Bias	R^2 (Pred)
NH_4^+	0.117	4.441e-16	0.969, 0.960	0.131	0.013	0.968
Na^+	0.119	-8.882e-16	0.953, 0.946	0.120	-0.028	0.953
K^+	0.118	4.441e-16	0.973, 0.966	0.136	-0.035	0.967

- Latent variables: 2
- Training set samples: 33
- Test set samples: 22

- Venetian blinds method (with 10 data splits and 1 samples per blind) was used for cross-validation of the training set.
- The PLS Toolbox running on Matlab was used for calculations.

Conclusions

- ✓ Affordable, sensitive, rapid, robust and reproducible paper-based transistors.
- ✓ Sensor analytical performance depends on the concentration of PEDOT:PSS.
- ✓ Sensors allow to discriminate ions with similar atomic radius and lipophilicity.
- ✓ Multiplex ion sensing using different ISM and a single gate.
- ✓ Multivariate model creation and internal validation to selectively detect and quantify the different ions in presence of interferences.

Future work

- External validation with real samples.

References

1. Rivnay, *et al. Nat. Rev. Mater.*, **2018**, *3*, 17086.
2. Ait Yazza, A.; Blondeau, P.; Andrade, F.J. *ACS Appl. Electron. Mater.*, **2021**, *3*, 1886-1895.
3. Han, *et al. Adv. Mater.*, **2020**, *32*, 2004790.
4. Ataş, H. B.; Kenar, A.; Taştekin, M. *Talanta*, **2020**, *217*, 121110.

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