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Development of an Experimental Model for Osmolarity Assessment and Evaluation of an Impedance-Based Prototype Against a Commercial Device

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INTRODUCTION

Tear osmolarity is a key biomarker in ocular surface disease, particularly in dry eye. Current point-of-care devices provide clinically useful information but are limited by variability and dispersion, especially at higher osmolarity levels. Impedance-based sensing offers a potential alternative by capturing a broader range of electrical properties related to solution composition.

Highly accurate osmolarity estimation using impedance-based sensing

PURPOSE

To develop a controlled experimental model for osmolarity assessment and to evaluate the performance of an impedance-based prototype (IMPEL) compared with a commercially available system (ScoutPro).

METHODS

A controlled laboratory model was designed using solutions with predefined concentrations of salts and electrolytes, covering a physiologically relevant osmolarity range.

Reference osmolarity values were established using calibration standards routinely employed for ScoutPro quality control.

Each solution was measured repeatedly using both the commercial device and the impedance-based prototype.

Predicted osmolarity values were compared to reference values to assess accuracy, deviation, and agreement.

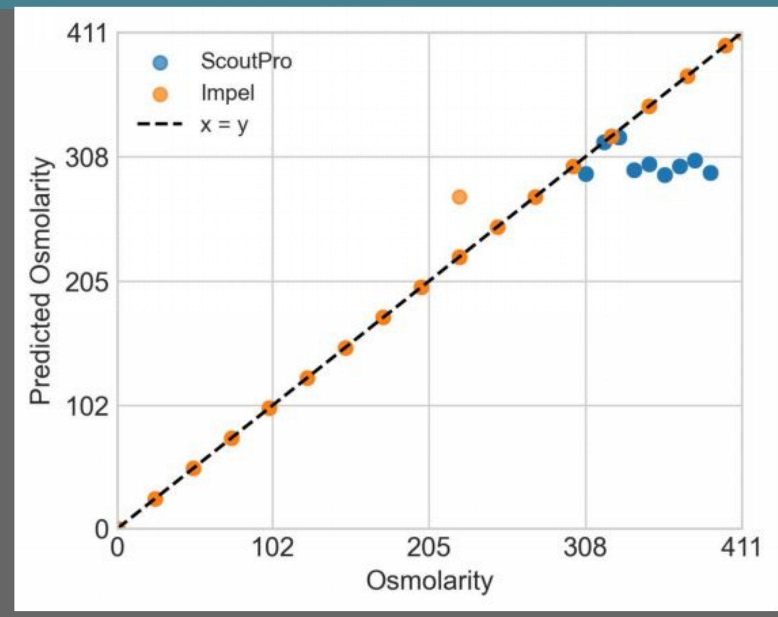

Figure 1. Osmolarity prediction accuracy

Comparison between measured and reference osmolarity values. IMPEL shows a highly linear response closely aligned with the identity line (x=y), while ScoutPro exhibits greater dispersion and deviation, particularly at higher osmolarity levels.

RESULTS

IMPEL demonstrated highly accurate and consistent osmolarity estimation across the full range of tested solutions, closely following reference values.

For a 308 mOsm/L solution, IMPEL reported 308 mOsm/L, while ScoutPro reported 294 mOsm/L.

Across the full spectrum, IMPEL showed strong linearity and minimal deviation from the identity line (figure 1).

ScoutPro measurements exhibited greater dispersion and increasing deviation at higher osmolarity levels.

Impedance sensing captures more than a single biomarker while maintaining accuracy in osmolarity estimation

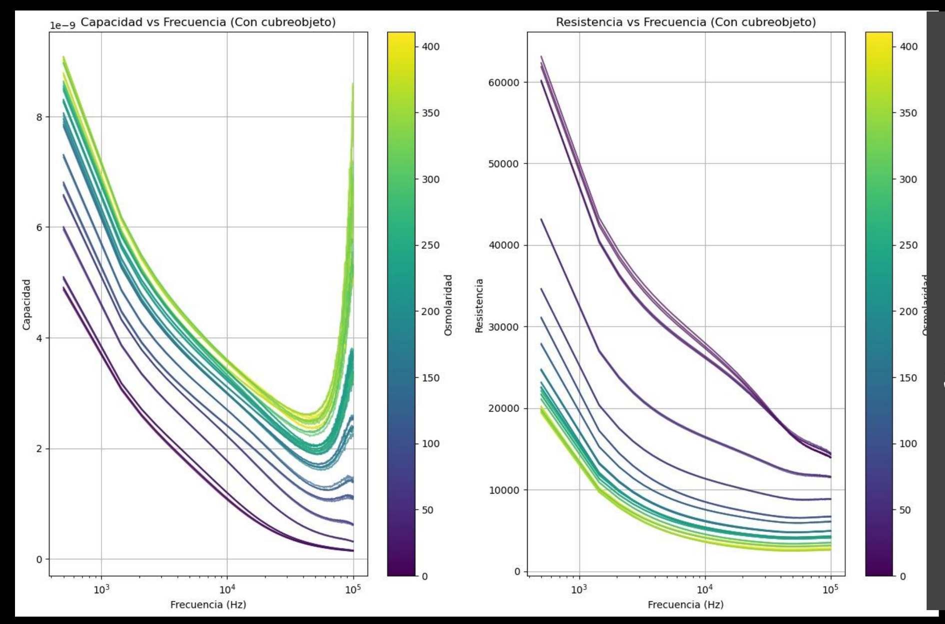

Figure 2. Frequency-dependent impedance behavior across osmolarity levels.
Electrical resistance and capacitance are shown as a function of excitation frequency across a range of osmolarity levels. Measurements were obtained from 500 Hz to 64 kHz. Both parameters exhibit consistent and systematic variation with osmolarity, indicating that impedance signatures encode compositional properties of the solution.

These findings support the use of multifrequency impedance as a robust and sensitive approach for osmolarity estimation.

CONCLUSIONS

A controlled experimental model for osmolarity assessment was successfully developed.

The impedance-based prototype demonstrated accurate and consistent estimation of osmolarity across a physiologically relevant range.

These findings support the feasibility of impedance-based sensing as a reliable alternative to existing commercial devices.

Disclosures for Bonetto, Bellotti, Saravia: Code P (Patent):US Patent: US 12,402,801 B2

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