Multi-analyte, Multiplexed, Multimodal, Minimally Invasive Biochip for Physiological Status Monitoring

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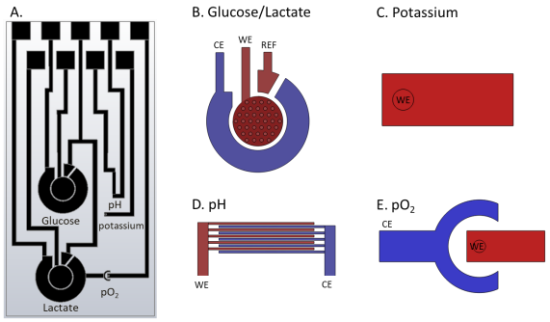
Keywords: biochip, modeling, multi-analyte, multiplexed, multimodal

ABATRACT (max. 300 words)

The temporal status of patients in the ER and ICU is important to their care. Decision support systems that continually measure and report the physiological status of key molecular indicators such as metabolite and cytokine profiles are emerging in delineating hemorrhagic shock states(*1*), sepsis, and post-surgical intervention. Equally important is the emergence of AI to augment decision support through the fusion of often disparate data sets into actionable scores.

A multi-analyte, multiplexed, multimodal minimally invasive biochip array - The Physiological Status Monitoring Biochip (PSM Biochip)(*2*) and accompanying computational model has been developed to serve as an adjunct to triage and allograft stratification (*3*). The AI-enabled Hemorrhage Intensive Severity and Survivability (HISS) score has been developed to immediately and continuously integrate measured metabolic indicators (glucose, lactate, pH, potassium, pO2) that are directly linked to the pathophysiology of hemorrhagic shock.

Microfabricated biochips (Fig. 1.) comprise five discrete sensor elements. Computational models of the five sensor elements employed COMSOL Multiphysics v6.0 run on a PC.



The glucose and lactate biosensors, employing glucose oxidase and lactate oxidase, were modeled as PPy/PPy^{+}•PSS^{-} mediated enzyme-amperometric reactions of linked Hill and Butler-Volmer equations. The potentiometric K^{+} sensor was modeled using the Nikolsky–Eisenman equation. The impedimetric pH response was modeled as a cationic(AEMA)-hydrogel-IME by coupling the Langmuir availability of ionic states of the ionogen with the Poisson's equation across the physiologic pH range. The pO_2 sensor was modeled using the microelectrode form of the Randles-Sevcik equation that was linked to a Langmuir adsorption of O_2 to nano-enabled Pt. The effect of overlapping electric and mass-transport fields on minimum feature size were examined. Figures of merit include limit of detection, sensitivity, dynamic range, and response time are being explored as a function of design parameters. All systems showed excellent agreement ($p>0.05$) with previously published data.

REFERENCES

1. A. Bhat *et al.*, *Journal of Translational Medicine* **18**, 1-17 (2020).
2. A. Guiseppi-Elie, *Analytical and Bioanalytical Chemistry* **399**, 403-419 (2011).
3. J. R. Aggas *et al.*, *Bioengineering* **10**, 434 (2023).