Near-Infrared spectroscopy for lactate detection: Exploring wearable device for real-time neonatal hypoxia monitoring

Huihui Lu[1,*], Jason Yang[1], Fergus McCarthy[2], Rhys Kelham[3], Patrick Doherty[3], Stefan Anderson-Engels[1], Ray Burke [1]

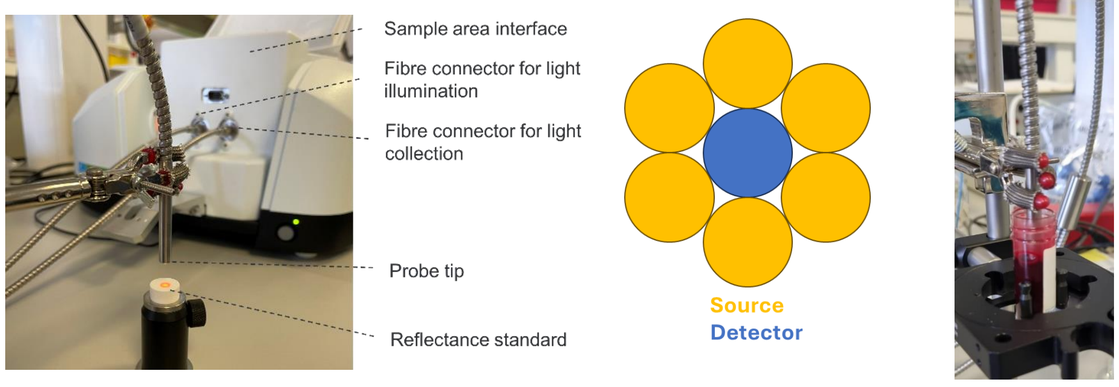
[1] Biophotonics @ Tyndall, IPIC, Tyndall National Institute, University College Cork, Cork, Ireland
[2] Anu Research Centre, Department of Obstetrics & Gynaecology, Cork University Maternity Hospital, University College Cork, Cork, Ireland
[3] Perkin Elmer Company, Chalfont Road, Seer Green, Buckinghamshire HP9 2FX UK

1. Introduction

- **Background**: Umbilical arterial lactate is a key biomarker associated with neonatal morbidity. Elevated lactate levels indicate fetal hypoxic distress requiring immediate delivery. Current assessment of fetal lactate levels via scalp blood-gas analysis is non-continuous, invasive, and error-prone.
- **Motivation**: To address the need for early detection of fetal hypoxia and associated comorbidities, we propose developing a wearable multimodal device for continuous monitoring of fetal pH and lactate. As an initial step, we explored the use of optical sensing technology for lactate monitoring.

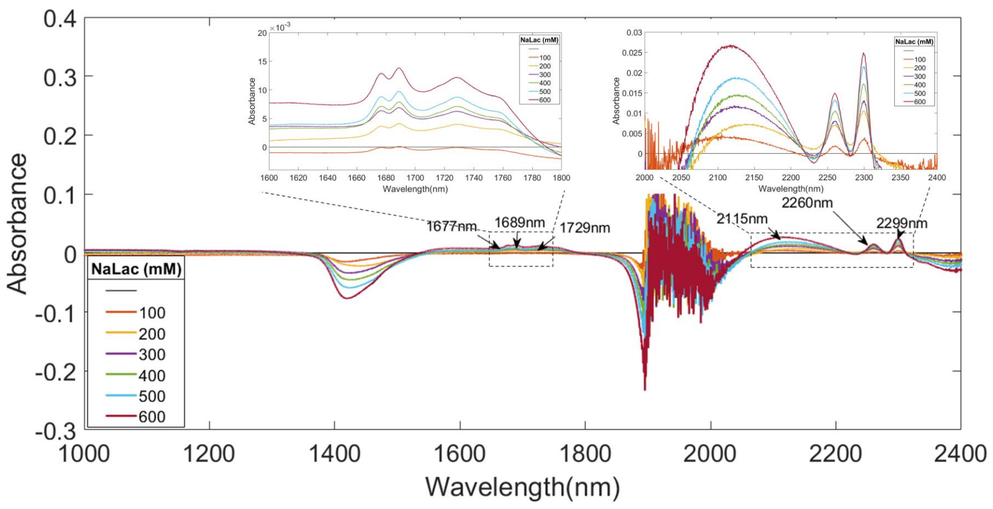
2. Methods

- **Instrument**: PerkinElmer *Spectrum-Two* FT-IR Spectrometer
- **Transmission Spectroscopy Setup**:
  - NaLac stock solution (600 mM) was serially diluted with PBS to obtain the concentration of lactate between 100 – 600 mM
  - Absorbance were collected in the 1000-2400nm with a 1 mm quartz cuvette
- **Reflectance Spectroscopy Setup**:
  - Bovine whole blood spiked with NaLac with concentrations from 0-60 mM
  - Fibre-coupled reflection probe with 6x sources and 1x detector fibre submerged under sample surface

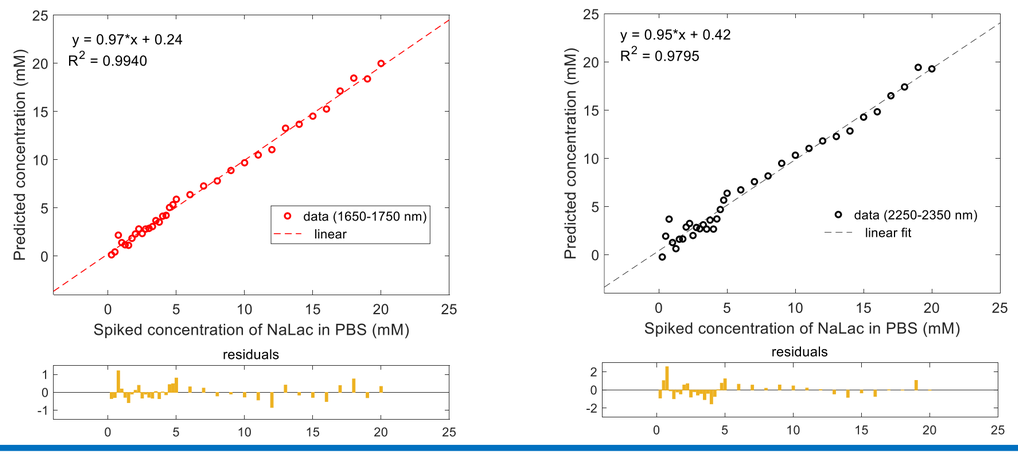


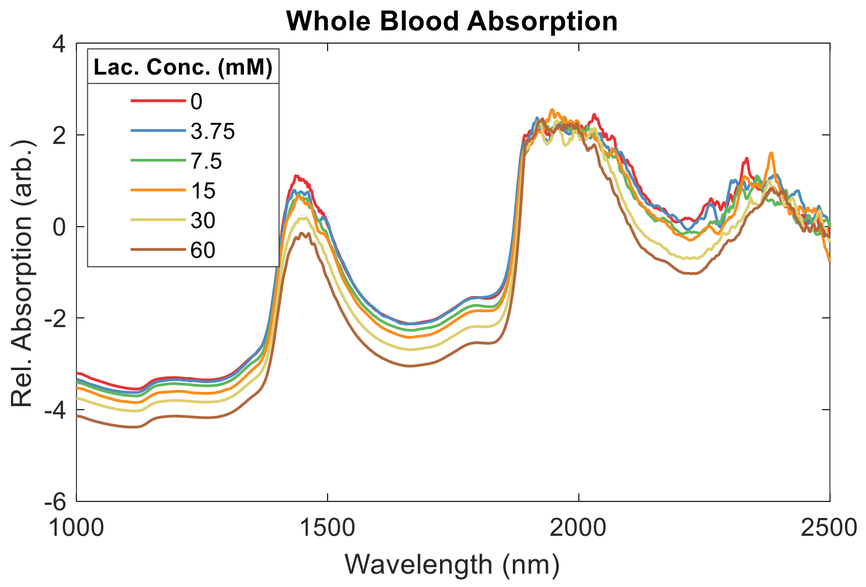
3. Output and Results

- **Identification of lactate spectral peaks in NIR range with transmission spectroscopy**

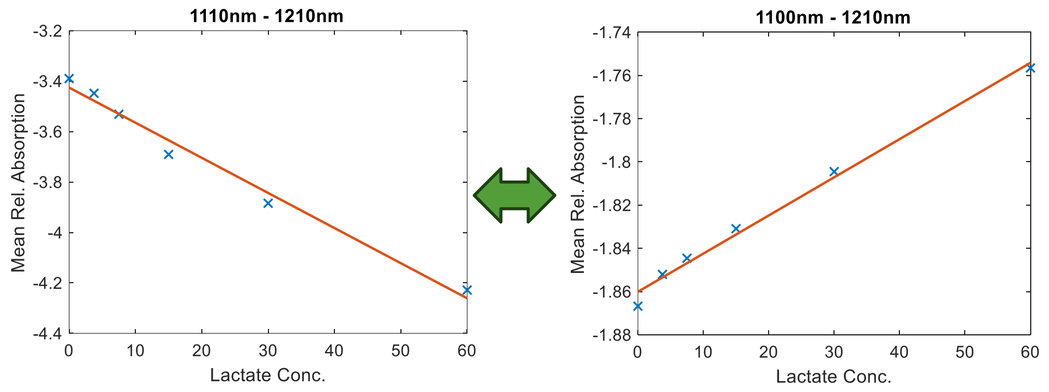


- **Predicted vs actual concentrations using PLS regression**

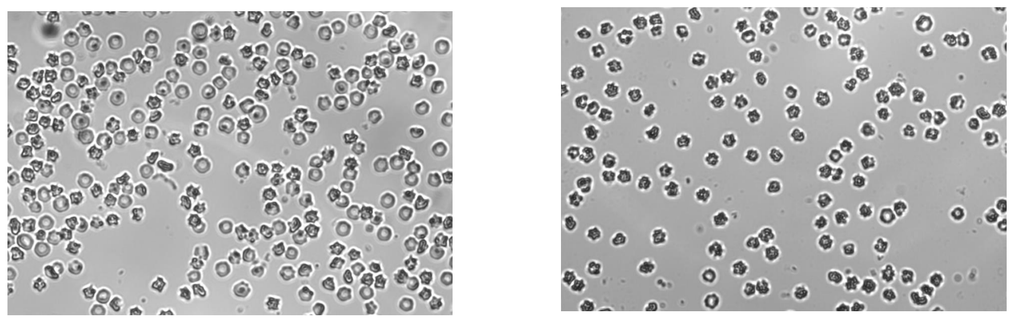




- **Reversed in reflectance mode vs. transmission mode**

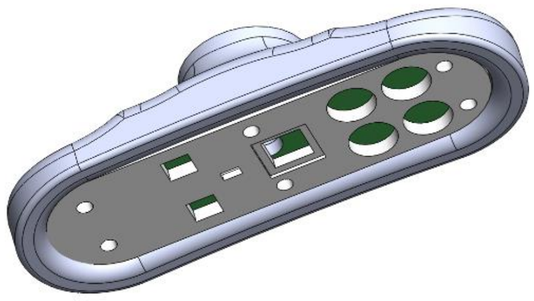


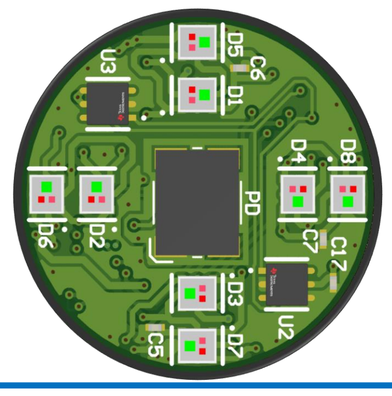
- **RBC shape change at high and low NaLac concentrations**



4. Conclusions & Future work

- Lactate exhibited absorbance peaks at 1650–1750 nm and 2250–2350 nm. PLS analysis using leave-one-out cross-validation achieved correlation coefficients of 0.99 and 0.97 between predicted and actual concentrations within these optical windows in transmission mode.
- Scattering changes caused by osmolarity-induced red blood cell shape variations were found to significantly affect reflectance signals
- This work provides a better understanding of the lactate optical behavior in the NIR range to recognize the merits and limitations of optical sensing technology for lactate detection.
- Future work will involve clinical sample testing, and exploring complementary techniques, such as Raman spectroscopy, to enhance clinical applicability.





Acknowledgements

This work is supported by a research grant from Enterprise Ireland under grant number CF-2022-2026-B and Research Ireland under Grant Number SFI/15/RP/2828, and Horizon Europe (Chips JU) PhotonMed under grant number 101139777.