N.I.C.O.L.A.S.
Oral Exam

February 12, 2020

Jude Franklin, Anthony Frederick, Chet Friday, Justin Mollison, Gregory Ridgel

Faculty Advisor: Dr. Franz Baudenbacher
Clinical Advisor: Dr. Susan Eagle

NICOLAS

Non-invasive

Continuous

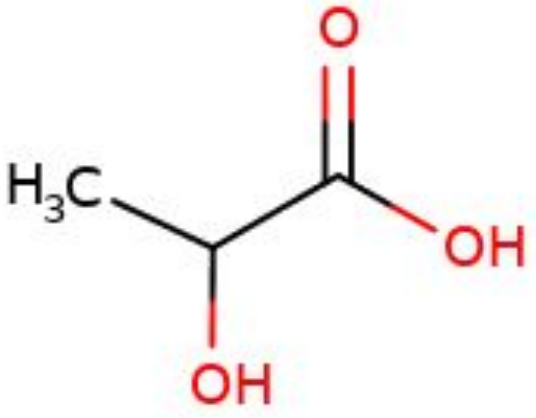
Optical

Lactic Acid

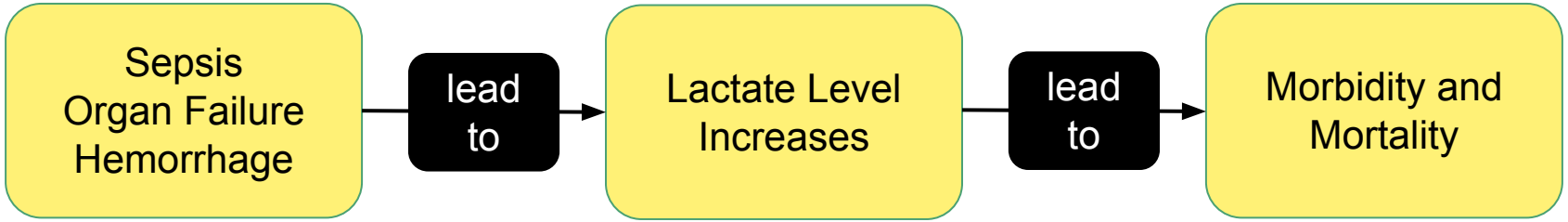
Sensor

Background

- Clinical biomarker used to measure tissue degradation
- Normal levels ~ 1 mM.
    - Relative > Absolute measurements



Lactic Acid
(2-hydroxypropanoic acid)



Problem Statement

- Currently, blood lactate levels are undersampled in clinical settings, leading to undetected spikes in lactate concentration which indicate the onset of sepsis, organ failure, and hemorrhage

Needs Assessment

Patient

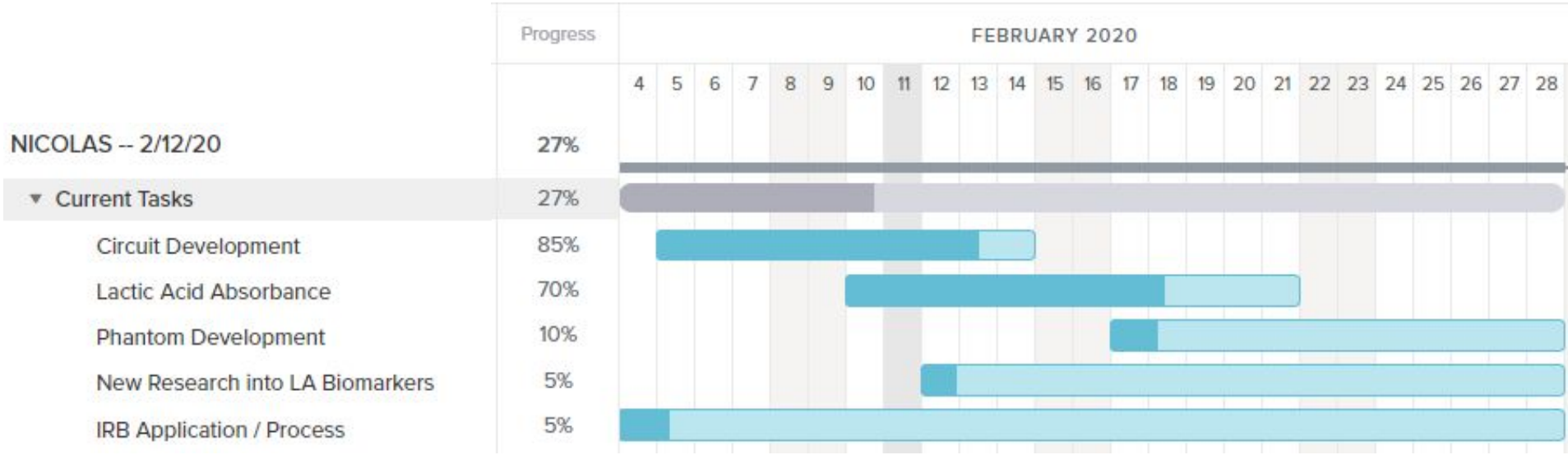
Insulated Device
Intermittent Pulses
Non-invasive

Practitioner

Continuous Sampling
Ease of Use
Clinical Application

System

Simplest Modality
Cost Effective & Portable
Integrate with Hospital Systems

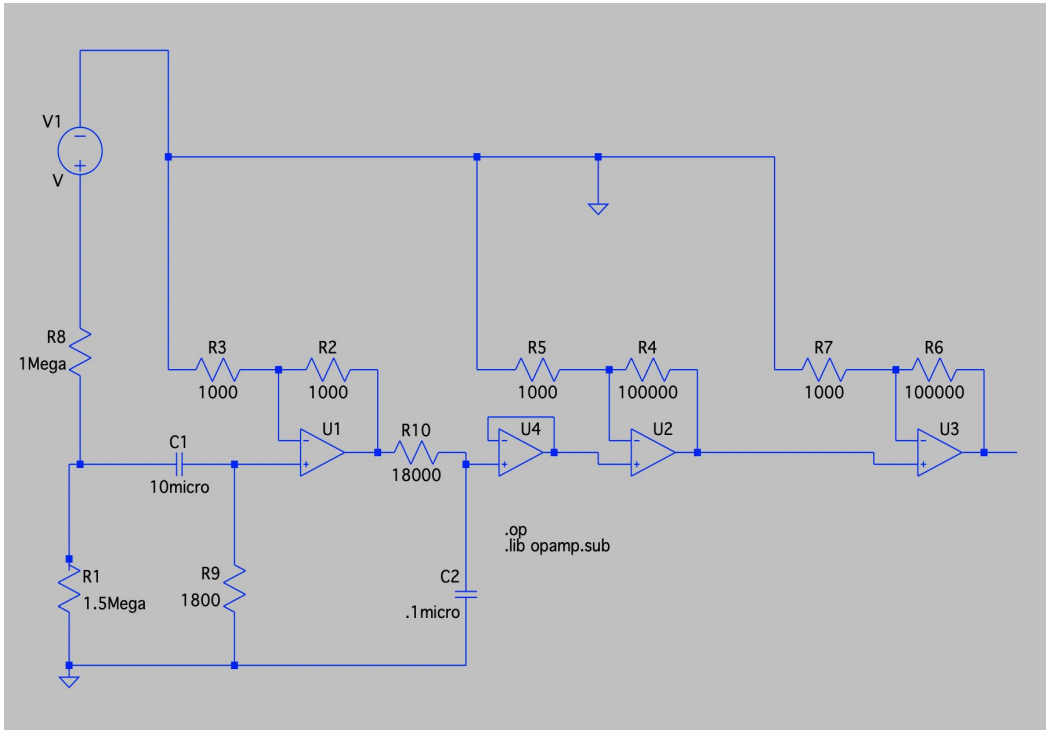

Progress
FEBRUARY 2020
4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28
NICOLAS -- 2/12/20
27%
Current Tasks
27%
Circuit Development
85%
Lactic Acid Absorbance
70%
Phantom Development
10%
New Research into LA Biomarkers
5%
IRB Application / Process
5%

This Week’s Progress:

- Circuit Troubleshooting
- New Phantom Design
- Lactate Absorbance Readings
- Other Lactic Acid Biomarkers

Circuit Troubleshooting

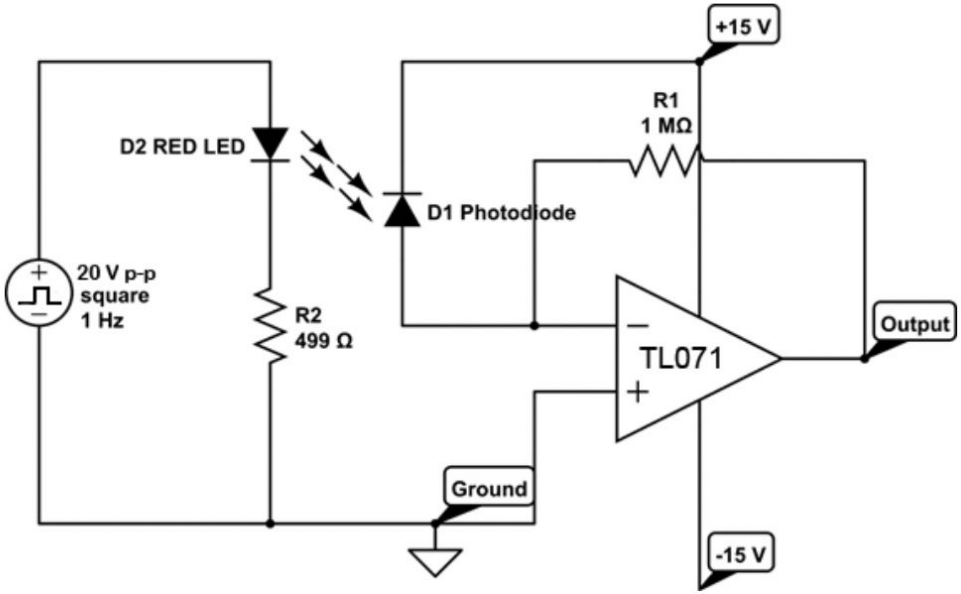
Current to Voltage Converter v1.1



Circuit Troubleshooting - Back to Basics

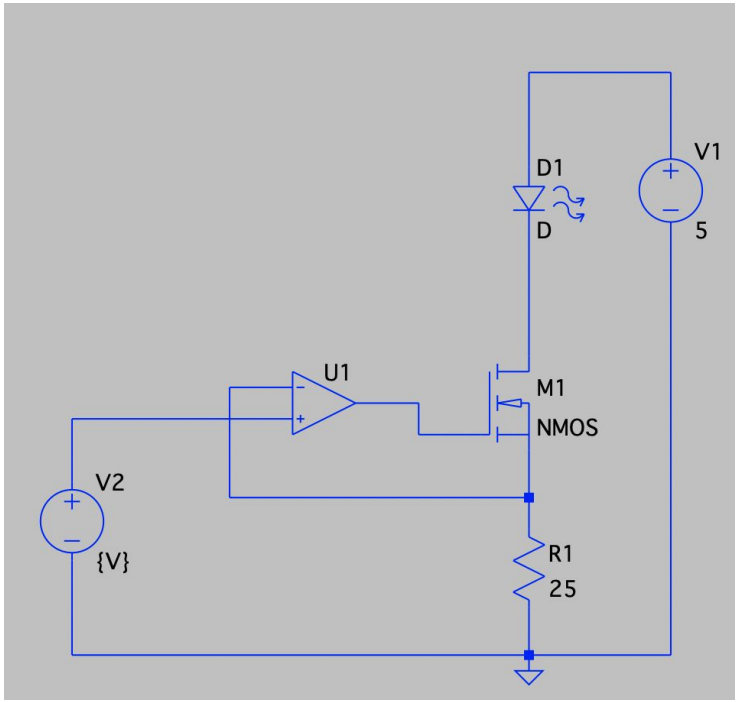
- Verified parts to be good using replacement technique in basic circuit
- Encountered filtering issues
  - Signal hard to distinguish from noise
  - Digital filters only provide solution for certain oscilloscopes
- Filtering solutions
  - Circuit housing to eliminate 60Hz noise
  - Transitioning to Labview readout for more robust signal processing

Basic IR - Photodiode Circuit

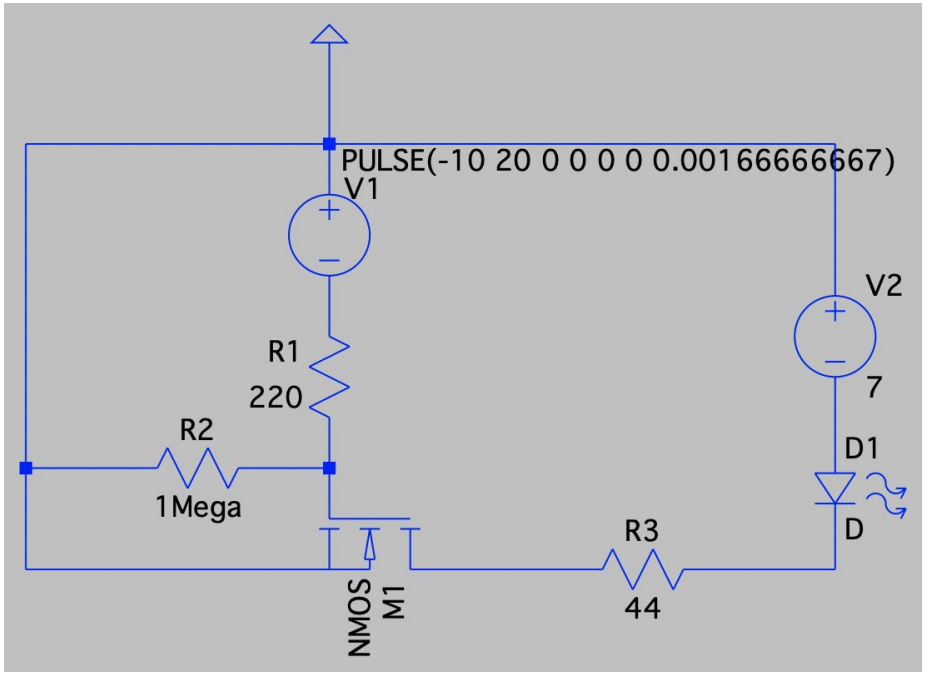


Circuit Troubleshooting - PCS v1.1

Pulsed Current Source v1.0



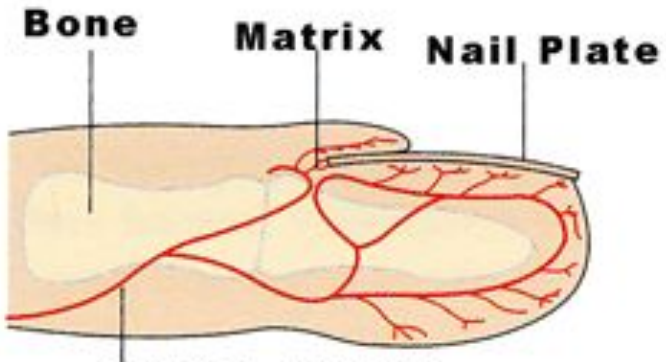
Pulsed Current Source (PCS) v1.1



Optical Path Length

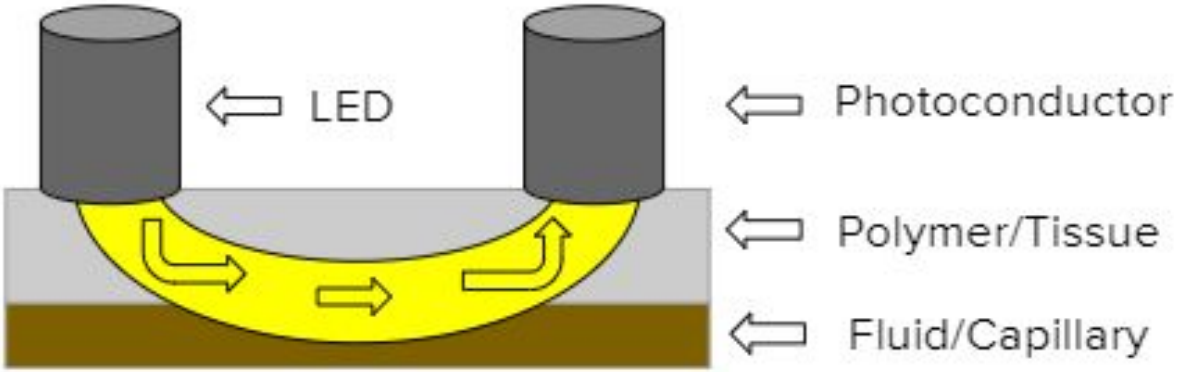
- Absorption coefficient of skin layers(epidermis and dermis)
  - μ_s= 8.31 cm^{-1}
  - μ_a = 5.75 cm^{-1}
  - μ_t= 7.412 cm^{-1}
  - Z= .088 cm
- Transmission would require a depth of 1.3 cm
- The fingernail skin thickness is .057 cm
  - Ideal for NIRS and reflectance

$$\mu_{eff} = \sqrt{(3 * (5.75 * 7.412))} = 11.31 cm^{-1}$$

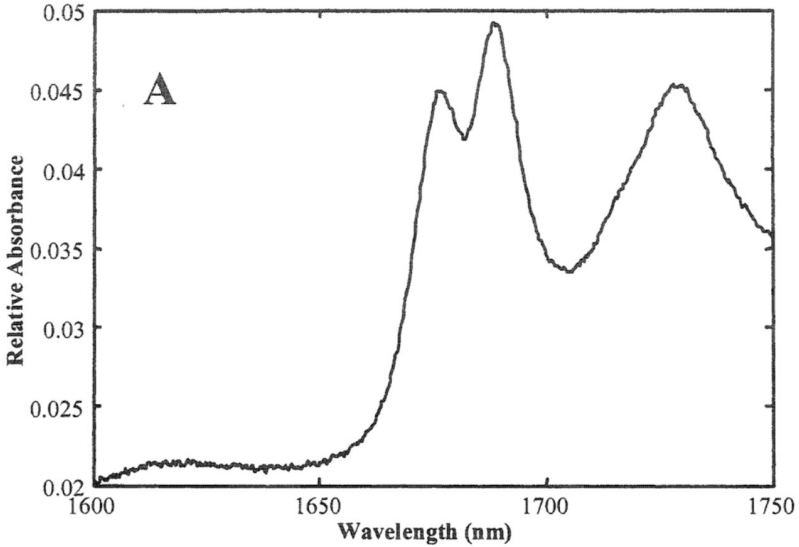


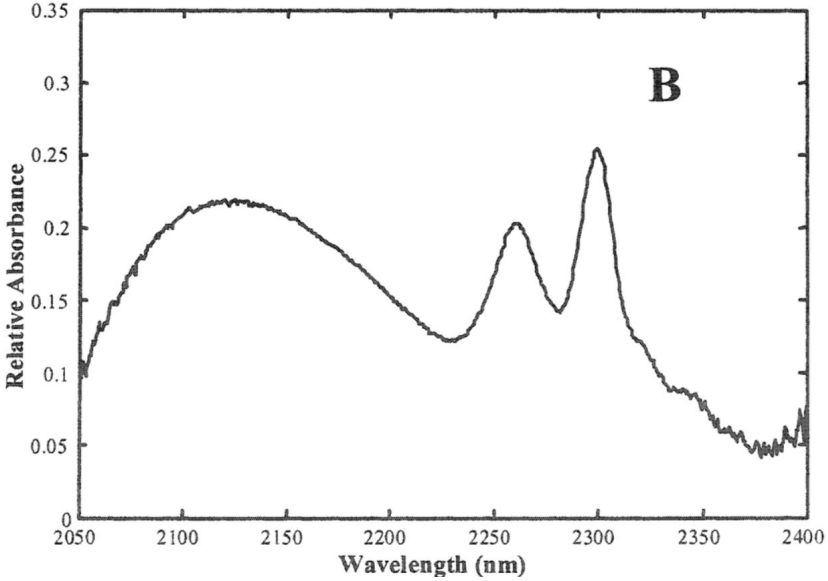
Phantom -- New Plans

- Depth Issues
  - Capillary Bed and IR-Penetration
  - Complications with prior design
- Microfluidics Option
  - Precise polymer depth
  - PMMA, PLA, PDMS
  - Depends on optical interactions

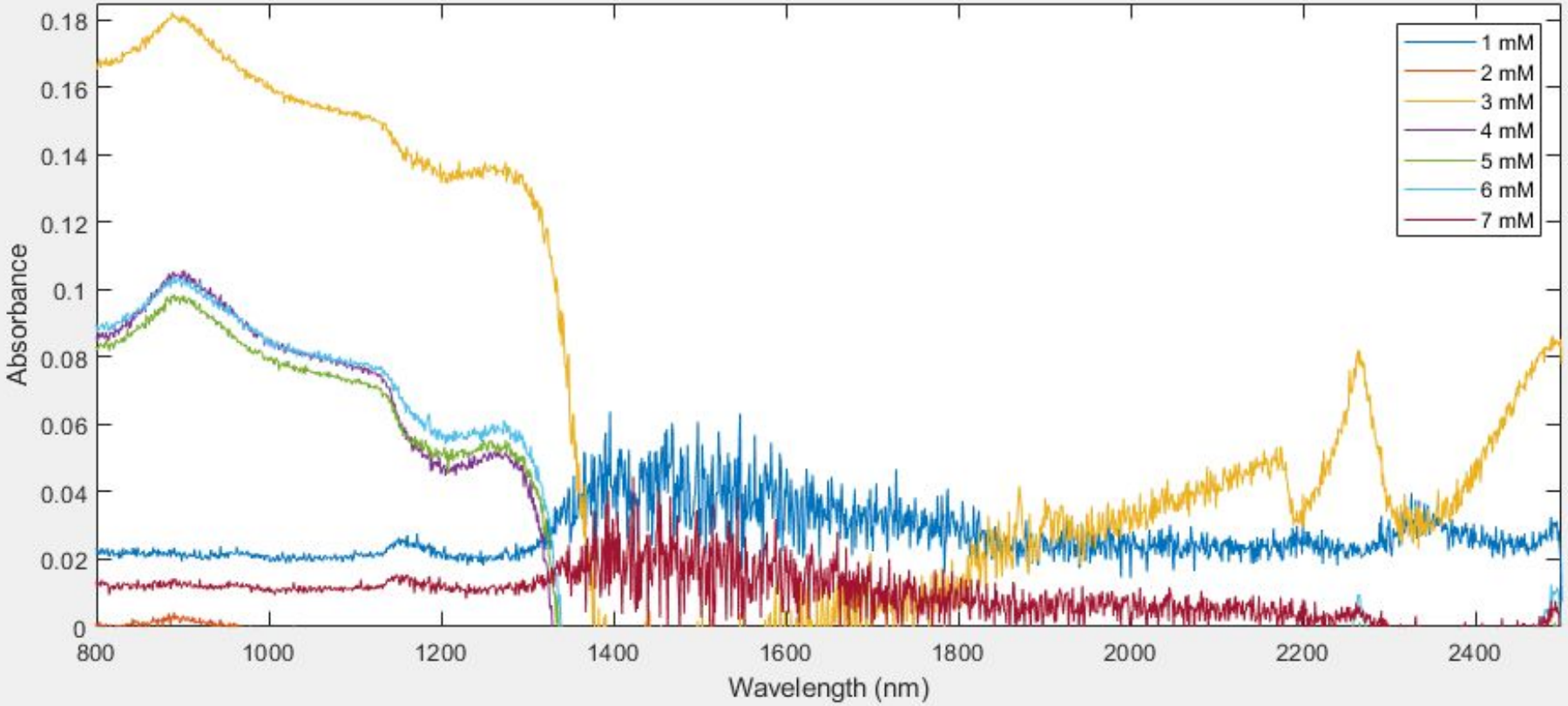


Lactate Absorbance In Literature



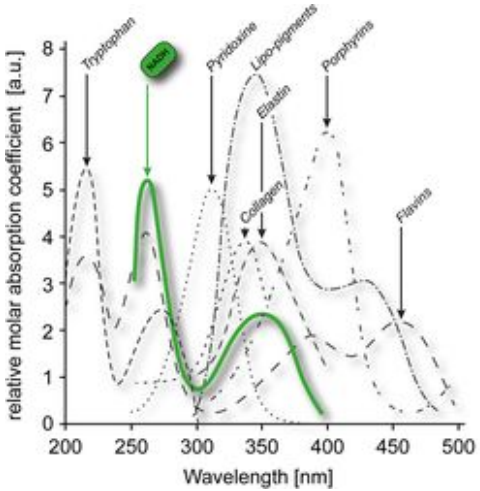


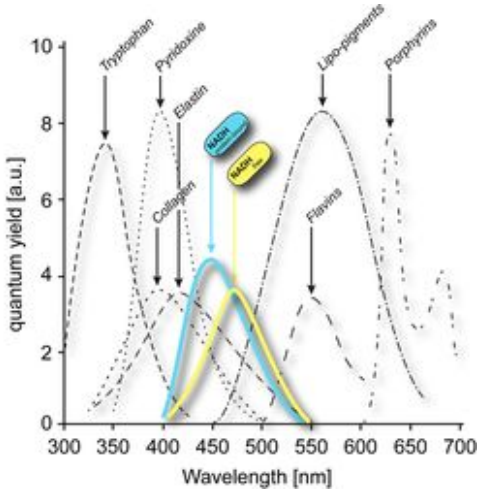
Lactate Absorbance (relative to baseline)



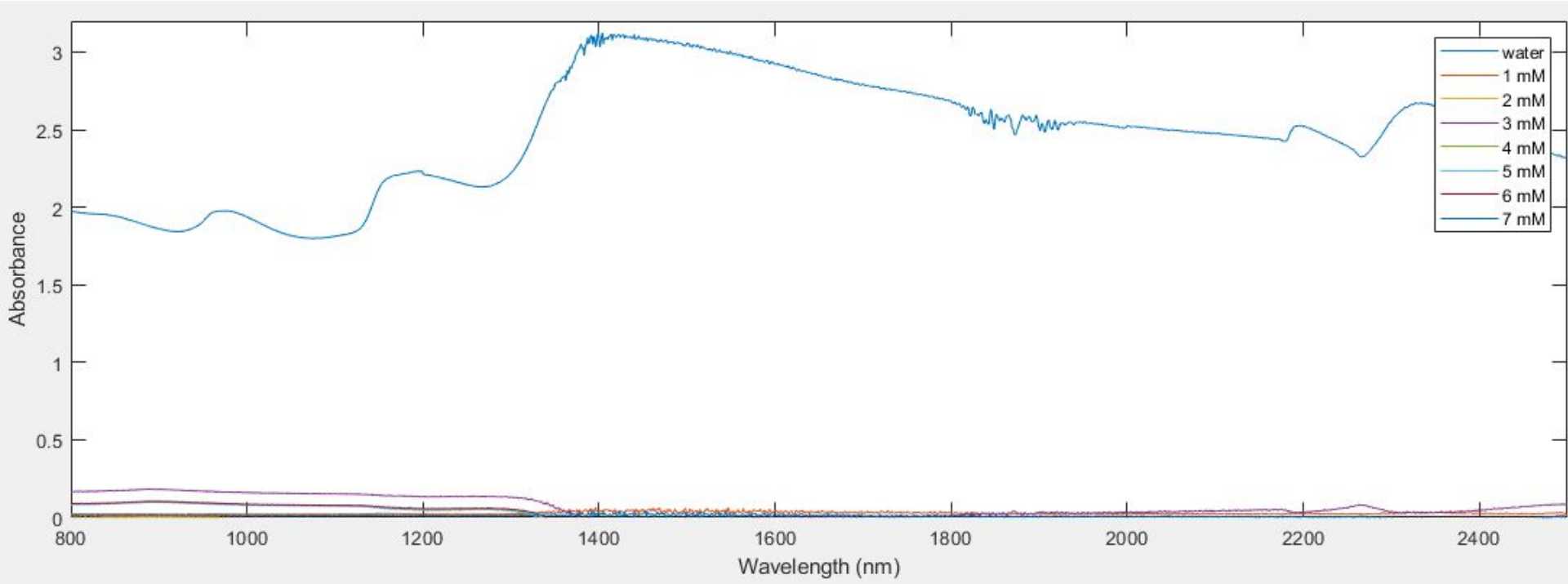
Other LA Biomarkers

- Lactate Dehydrogenase
- FADH/NADH
  - Can be used as a biomarker for metabolism
- Buffer capacity
  - Determine how LA acidity varies
  - Won’t work bc lactate PH is around 7
  - Won’t be seen above bicarbonate
- Glycogen
- Measuring in organic solvents





Lactate Absorbance with Water Baseline



Lactate Absorbance Issues

- Magnitude of Water Absorbance vs. Magnitude of Lactate Absorbance
  - Signal Mirroring
  - Signal well within machine error
- Lactate Sensing Capability of our Device

Proposed Solutions

- Full spectrum in aqueous solution to confirm values
- Measuring in plasma and inorganic solvents
- Metabolic fluorescence
  - Bind something with affinity to LA or a biomarker
  - Take the transmittance/absorbance
- Correlated Study
  - Model of metabolism using other studies
    - FADH/NADH
    - NIRS will work for this
- Digital signal processing
  - Fourier transform, derivative filters of our signal, using various window widths