



**COLLEGE OF ENGINEERING
AND COMPUTER SCIENCE**
FLORIDA ATLANTIC UNIVERSITY

Announces the Ph.D. Dissertation Defense of

Darryl Dieujuste

for the degree of Doctor of Philosophy (Ph.D.)

“Microfluidic Electrical Impedance Technology for Point-of-Care Assessment of Sickle Cell Disease”

June 29, 2023, 2:00 p.m.

In Person:

**Engineering West (EG-36), Room #187
777 Glades Road
Boca Raton, FL**

Virtual via Zoom:

<https://fau-edu.zoom.us/j/82885555870?pwd=VmdOZzNvMDNySmJHVmpicjZmZkc4Zz09>

Meeting ID: 828 8555 5870

Passcode: j51Cms

DEPARTMENT:

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Sarah Du, Ph.D., Chair

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ABSTRACT OF DISSERTATION

Microfluidic Electrical Impedance Technology for Point-of-Care Assessment of Sickle Cell Rheology

Sickle Cell Disease (SCD) is a genetic disease that affects approximately 100,000 people in the USA and millions worldwide. The disease is defined by a mutation in hemoglobin, the red blood cell's oxygen carrying component. Under hypoxic (low oxygen) conditions, the mutated hemoglobin (known as HbS) polymerizes into rigid fibers that stretch the cell into a sickle shape. These rigid cells can occlude blood vessels and cause an individual immense pain. Currently, no point-of-care devices exist in the market for assisting those with SCD. Using microfluidics with custom designed portable impedance measuring hardware we can achieve label-free in vitro analyses of SCD rheology.

This dissertation presents two impedance-based devices for finger-prick volume blood testing, including a microflow cytometer for SCD diagnostics and a vaso-occlusion tester for monitoring blood flow activities. First, the microflow cytometer is validated by measuring the electrical impedance of individual cells flowing through a narrow microfluidic channel. Cellular impedance is interpreted by changes in subcellular components due to oxygen association-dissociation of hemoglobin, using an equivalent circuit model and Multiphysics simulation. Impedance values of sickle cells exhibit remarkable deviations from normal blood cells. Such deviation is quantified by a conformity score, which allows for measurement of SCD heterogeneity, and potentially disease severity. Findings from this study demonstrate the potential for SCD screening via electrical impedance. Second, a vaso-occlusion tester is validated by measuring the impedance response of blood flow within a microfluidic mimic of capillary bed. The integrated electrical impedance sensor allows real-time rheological measurement that is specific to sickle blood, when equipped with hypoxia control. Cell sickling events attributed to capillary obstructions are observed within less than 20 s, facilitating rapid vaso-occlusion testing (within 1 min). A

full rheological transition from steady flow, vaso-occlusion, to flow recovery in response to a brief (70 s) deoxygenation-reoxygenation process is detected in sickle blood. Sensitivity of impedance detection of vaso-occlusion is obtained using both natural sickle cells and sickle cell simulants. Performance evaluation of the device at frequencies between 10 kHz and 500 kHz suggests the feasibility of further miniaturization and portability of the entire system, thus facilitating its application at point-of-care settings. The tester can be potentially used to predict the onset of a painful episode and to assess the efficacy of pharmaceutical drugs in ameliorating painful vaso-occlusion.

BIOGRAPHICAL SKETCH

Born in Miami, Florida

B.S., Florida Atlantic University, Boca Raton, Florida, 2016

M.S., Florida Atlantic University, Boca Raton, Florida, 2018

Ph.D., Florida Atlantic University, Boca Raton, Florida, 2023

CONCERNING PERIOD OF PREPARATION

& QUALIFYING EXAMINATION

Time in Preparation: 2019 - 2023

Qualifying Examination Passed: Spring 2020

Published Papers:

- **D. Dieujuste**, E. Du, "Electrical Impedance Based Vaso-Occlusion Tester". Manuscript in Progress
- M. Lin, R. Paul, M. Abd, J. Jones, **D. Dieujuste**, H. Chim, E. Engeberg, "Feeling the beat: a smart hand exoskeleton for learning to play musical instruments," Accepted with *Frontiers in Robotics and AI*. doi: 10.3389/frobt.2023.1212768. 2023
- Y. Qiang, **D. Dieujuste**, J. Liu, E. Du, "Rapid electrical impedance detection of sickle cell vaso-occlusion in microfluidic device," Accepted with *Biomedical Microdevices*. doi: 10.1007/s10544-023-00663-1. 2023
- **D. Dieujuste**, Y. Qiang, and E. Du, "A portable impedance microflow cytometer for measuring cellular response to hypoxia," *Biotechnology and Bioengineering*, vol. 118, no. 10, pp. 4041-4051, 2021.
- **D. Dieujuste**, J. Liu, E. Du, and O. A. Alvarez, "Development of a Low-Cost Electrical Impedance-Based Microflow Cytometer," ed: American Society of Hematology Washington, DC, 2019.
- Y. Qiang, J. Liu, **D. Dieujuste**, K. Ramsamoj, and S. E. Du, "Continuous cell sorting by dielectrophoresis in a straight microfluidic channel," in *ASME International Mechanical Engineering Congress and Exposition*, 2018, vol. 52026: American Society of Mechanical Engineers, p. V003T04A026.
- Y. Qiang, J. Liu, F. Yang, **D. Dieujuste**, and E. Du, "Modeling erythrocyte electrodeformation in response to amplitude modulated electric waveforms," *Scientific reports*, vol. 8, no. 1, p. 10224, 2018.

Patents:

- Du, Y. Qiang, **D. Dieujuste**, and J. Liu, "Vascular occlusion testing device," US Patent App. 17/313,235, 2022.
- E. Du, **D. Dieujuste**, J. Liu, and Y. Qiang, "Portable Electrical Impedance-Based Blood Testing Device for Diagnosis and Monitoring Sickle Cell Disease," US Patent App. 16/585,897, 2020.