Scientific Memo

University of Medicine and Pharmacy "Carol Davila" Bucharest (Romania)

To: Doctoral School Committee
From: Dharm Singh Yadav
Date: 26.03.2025
Subject: Scientific Progress and Thesis Summary

Introduction

This scientific memo outlines my scientific progress, research contributions, and the scope of my doctoral thesis, as required by the UMFCD Doctoral School for thesis submission. My work, conducted under the Marie Skłodowska-Curie Actions (MSCA) Innovative Training Network, focuses on interdisciplinary biophysics, integrating optical and electrical techniques for manipulation, characterization and separation of cells, with applications in retinal pigment epithelial (RPE) cell-based transplantation and cell replacement therapies.

Research Objectives

The primary objectives of my thesis, titled "**Use of Optical Tweezers and Dielectrophoresis for Retinal Pigment Epithelial Cells Characterization and Separation Toward Cell Replacement and Transplantation Therapy,**" are:

1. **Designed and studied an in vitro model for Age-Related Macular Degeneration (AMD):** Conducted experiments and COMSOL simulations to characterize and separate healthy RPE cells in AMD model using population dielectrophoresis, contributing to advancements in cell replacement therapies.
2. **Designed and built a dual-trap system:** Designed and built a dual trapping system by integrating optical tweezers and dielectrophoresis on an inverted microscope, combined with a custom 3D-printed microfluidic lab-on-a-chip for precise manipulation and analysis of single cells.
3. **Measured optical trapping forces on eukaryotic cells:** Utilized the dual trap to directly quantify optical trapping forces and to measure single-cell optical properties (refractive indices).

Key Achievements

1. **Instrumentation:**
    - Designed and built a novel opto-electric trap integrating optical tweezers, DEP, and microfluidics on an inverted microscope platform.
    - Enabled direct calibration of optical trapping forces on eukaryotic cells and simultaneous measurement of DEP responses.

2. **Biological Models:**
    - Established *in vitro* AMD models using hydrogen-peroxide-induced oxidative stress in RPE cells.
    - Developed a co-culture system (primary pig RPE + retinal tissue) during a secondment at Vision Institute, Paris to study degenerative symbiosis (retina-RPE).
3. **Analytical Contributions:**
    - Demonstrated DEP as a tool for distinguishing peroxidized (AMD-like) RPE cells from healthy populations (*BMC Ophthalmology*, 2024).
    - Quantified optical trapping forces on RPE cells using DEP-based calibration (*Romanian Reports in Physics*, accepted 2025).

Publications and Dissemination

1. **Peer-Reviewed Papers:**
    - Optical Tweezers in Biomedical Research (*Journal of Medicine and Life*, 2024).
    - Dielectrophoretic Characterization of Peroxidized RPE Cells (*BMC Ophthalmology*, 2024).
    - Estimation of Optical Trapping Force Using DEP (*Romanian Reports in Physics*, 2025).
2. **Conferences:** 10+ oral/poster presentations at international venues (e.g., SFN 2022-USA, ERM 2023-Germany, JNS 2023-Japan, SNN 2024-Romania).
3. **Awards:** MSCA-ITN Fellowship (2021), Best Poster Award (National Biophysics Conference, 2022).

Conclusion

This research contributes in advancing biophysical tools for cell analysis and offers possibility to improve RPE cell-based therapies in retinal degenerative diseases. The integration of optical and electrical trapping provides a versatile platform for analysis of single-cells contributing to biomedical applications.

Signature:
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