



**University  
of Victoria**

Graduate Studies

# PROGRAMME

The Final Oral Examination  
for the Degree of

DOCTOR OF PHILOSOPHY  
(Department of Mechanical Engineering)

## **Nima Khadem Mohtaram**

2008 Iran Polymer and Petrochemical Institute  
2006 Tehran Polytechnic

MSc.  
BSc.

“Development of Multiscale Electrospun  
Scaffolds for Promoting Neural Differentiation of  
Induced Pluripotent Stem Cells”

**Tuesday, December 2, 2014  
3:00 PM**

**Engineering Office Wing, Room 106**  
(IESVic Design Room, located inside EOW-108)

Supervisory Committee:

Dr. Stephanie Willerth  
Department of Mechanical Engineering, UVic (Supervisor)  
Dr. Martin Byung-Guk Jun  
Department of Mechanical Engineering, UVic (Member)  
Dr. Bob Chow  
Department of Biology, UVic (Outside Member)  
Dr. Alex Brolo  
Department of Chemistry, UVic (Outside Member)

External Examiner:

Dr. Rizhi Wang, Department of Material Engineering, UBC

Chair of Oral Examination:

Dr. E. Paul Zehr  
School of Exercise Science, Physical and Health Education, UVic

## **Abstract**

Electrospun biomaterial scaffolds can be engineered to support the neural differentiation of induced pluripotent stem cells. As electrospinning produces scaffolds consisting of nano or microfibers, these topographical features can be used as cue to direct stem cell differentiation. These nano and microscale scaffolds can also be used to deliver chemical cues, such as small molecules and growth factors, to direct the differentiation of induced pluripotent stem cells into neural phenotypes. Induced pluripotent stem cells can become any cell type found in the body, making them a powerful tool for engineering tissues. Therefore, a combination of an engineered biomaterial scaffold with induced pluripotent stem cells is a promising approach for neural tissue engineering applications. As detailed in this thesis, electrospun scaffolds support the neuronal differentiation of induced pluripotent stem cells through delivering the appropriate chemical cues and also presenting physical cues, specifically topography to enhance neuronal regeneration.

This thesis seeks to evaluate the following topics: multifunctional electrospun scaffolds for promoting neuronal differentiation of induced pluripotent stem cells, neuronal differentiation of human induced pluripotent stem cells seeded on electrospun scaffolds with varied topographies, and controlled release of glial cell-derived neurotrophic factor from random and aligned electrospun nanofibers.

## **Awards, Scholarships, Fellowships**

2011 – 2014 University of Victoria, Graduate Student Award  
2011 – 2014 University of Victoria, Research Assistantship

## **Presentations**

1. Mohtaram N.K. et al. "Melt Electrospun Microfiber Scaffolds with Novel Architecture for Neuronal Differentiation of Human Induced Pluripotent Stem Cells ", 31st Annual Meeting of The Canadian Biomaterials Society, Halifax, NS, Canada, 2014. ( This talk was awarded as the best talk in the tissue engineering session at the CBS meeting in Halifax)
2. Mohtaram N.K. et al. "Encapsulated Polymeric Microspheres for Promoting Neural Differentiation of Pluripotent Stem Cells", 31st Annual Meeting of The Canadian Biomaterials Society, Halifax, NS, Canada, 2014.
3. Mohtaram N.K. et al. Development of Micro and Nanostructured Biomaterial Scaffolds for Neural Differentiation of Induced Pluripotent Stem Cells", 3rd Student-based Biomaterials symposium, Vancouver, BC, Canada, 2014. (Invited Speaker)
4. Mohtaram N.K. et al. "Fabrication and Characterization of Hybrid Biomaterial Nerve Conduits for Neural Differentiation of Induced Pluripotent Stem Cells", 30th Annual Meeting of The Canadian Biomaterials Society, Ottawa, ON, Canada, 2013
5. Mohtaram N.K. et al. "Multifunctional Electrospun Scaffolds for Promoting Neural Differentiation of Embryonic and Induced Pluripotent Stem Cells" BC Stem Cell and Regenerative Medicine Initiative, Simon Fraser University (SFU), Vancouver, BC, Canada , 201
6. Mohtaram N.K. et al. Nanofabrication of Electrospun Fibers for Controlled Release of Neural Bioactive Agents", 8th International Conference on Micro Manufacturing, Victoria, BC, Canada, 2013
7. Mohtaram N.K. et al. Parametric Studies of Melt Electrospinning Poly( $\epsilon$ -caprolactone) Fibers for Tissue Engineering Applications", 8th International Conference on Micro Manufacturing, Victoria, BC, Canada, 2013

## **Publications**

1. Mohtaram, N., Ko, J., King, C., Sun, L., Muller, N., Jun, M., Willerth, S.M. Neuronal Differentiation of Human Induced Pluripotent Stem Cells Using Multiscale Electrospun Scaffolds. Under review at JBMR.

2. Mohtaram, N., Ko, J., Rattray, D., O'Neil, P., Rajwani, A., Vasandani, R., Agbay, A., Jun, M., Willerth, S.M. Controlled Release of Glial cell-derived Neurotrophic Factor from Aligned Electrospun Nanofibers. In preparation, Journal of Neural Engineering.
3. Mohtaram, N., Ko, J., Montgomery, A., Carlson, M., Sun, L., Wong, A., Robinson, M., Jun, M., and Willerth, S.M. Multifunctional Electrospun Scaffolds for Promoting Neuronal Differentiation of Induced Pluripotent Stem Cells. Accepted for publication by the Journal of Biomaterials and Tissue Engineering in July 2014.
4. Ko, J., Mohtaram, N., Lee, P., Willerth, S.M., and Jun, M. Using mathematical modeling to control topographical properties of poly ( $\epsilon$ -caprolactone) melt electrospun scaffolds II. In preparation, Journal of Micromechanics and Microengineering.
5. Ko, J., Bhullar, S., Mohtaram, N., Willerth, S.M., and Jun, M. Using mathematical modeling to control topographical properties of poly ( $\epsilon$  caprolactone) melt electrospun scaffolds. Journal of Micromechanics and Microengineering. 2014 April (24) 065009.
6. Agbay, A., Mohtaram, N., and Willerth S.M. Controlled release of glial cell line-derived neurotrophic factor from poly ( $\epsilon$ caprolactone) microspheres. Drug Delivery and Translational Research. April 2014, Volume 4, Issue 2, pp 159-170.
7. Ko, J., Mohtaram, N., Ahmed, F. Carlson, M., Willerth S.M. and Jun M. Fabrication of multi-scale topographies using melt electrospinning for stem cell-based tissue engineering applications. Journal of Biomedical Science Polymer Edition. 2014 Jan;25(1):1-17.
8. Montgomery, A., Agbay, A., Edgar, J.M., Gabers, N., Gomez, J.C., Mohtaram, N., King, C., Mitchell, A., Rajwani, A., Rattray, D., Robinson, M., Shapka, A., Sun, L., Wong, A. and Willerth, S.M. Combining protein-based biomaterials with stem cells for spinal cord injury repair. OA Stem Cells. 2014 Jan 18;2(1):1
9. Mohtaram, N., Montgomery, A., and Willerth, S.M. Biomaterial based drug delivery systems for controlled release of neurotrophic factors. 2013 Apr;8(2):022001. doi: 10.1088/1748-6041/8/2/022001.
10. Mohtaram, N.K., Montgomery, A.L., Gomez, J.C., Agbay, A. and Willerth, S.M. Neural tissue engineering applications. Accepted for publication in the Encyclopedia of Biomedical Polymers and Polymeric Biomaterials. CRC Press.
11. Panahi Joo, Y., Mohtaram, N.K., Willerth, S.M., Soluk, A., A review on stem cells and other cells for the treatment of spinal cord injury. In preparation, Journal of Neurotrauma.