PROGRAMME

REVISED
The Final Oral Examination
for the Degree of

DOCTOR OF PHILOSOPHY
(Department of Mechanical Engineering)

Junghyuk Ko
2011  University of Victoria  MASc
2007  University of Konkuk  BEng

“Melt electrospinning using Polycaprolactone (PCL) polymer for various applications: Experimental and Theoretical analysis”

Friday, December 12th, 2014
4:00PM
Engineering Office Wing, Room 502

Supervisory Committee:
Dr. Martin B.G. Jun
Department of Mechanical Engineering, UVic (Supervisor)
Dr. Stephanie M. Willerth
Department of Mechanical Engineering, Division of Medical Science UVic (Member)
Dr. Chris Papadopoulos
Department of Electrical and Computer Engineering, UVic (Outside Member)

External Examiner:
Dr. Woo Soo Kim,
School of Mechatronics Systems Engineering, SFU

Chair of Oral Examination:
Dr. Chris Lalonde, Department of Psychology, UVic
Abstract

This thesis presents melt electrospinning technique to fabricate highly porous and controllable poly (ε-caprolactone), PCL, microfibers for tissue engineering applications and rehabilitation applications. Electrospinning without solvents via the melt may be attracting for tissue engineering of cell constructs where solvent accumulation or toxicity is a worry. It is also able to produce controllable microfibers. However, fiber diameters are relatively big from melt electrospinning process, compared to the fibers from solution electrospinning. The typical microfiber diameter from melt electrospinning was reported approximately 0.1mm. To develop melt electrospinning technique, we focus on the design of melt electrospinning setup based on numerical analysis using Solidworks 2013 simulation package and practically establish melt electrospinning setup and thermal control system for accurate experiments. One of main purposes of this thesis is the build-up of mathematical modeling to control and predict the electrospun microfiber via a better understanding of the parameters such as nozzle diameter, applied voltage, distance between nozzle and counter electrode, temperature, flow rate, linear transitional speed and etc. The model composes of three parts: 1) melt electrospinning process modeling, 2) fibrous helix movement modeling, and 3) build-up of microfibers modeling. The melt electrospinning process modeling describes an electric field, the shape of jet continuously changes and the polymer melt is stretched into a Taylor cone and a straight jet. The fibrous helix movement modeling describes movement of electrospun microfibers influenced by Lorentz force, which moves along helix pattern. Lastly, the build-up microfiber modeling describes the accumulation of the extruded microfibers on flat and round counter electrodes based on physical forces. These models are verified by experimental data from our own customized melt electrospinning setup. Moreover, the fabricated scaffold is tested by seeding neural progenitors derived from murine R1 embryonic stem cell lines and it demonstrates the potential of scaffolds for tissue engineering applications. To increase cell attachment and proliferation, highly porous microfibers are fabricated by combination of melt electrospinning and particular leaching technique. Finally, auxetic stretchable PCL force sensors are fabricated by melt electrospinning for hand rehabilitation. These stretchable sensors can be manageable by applied external loads or strain and also be attachable on the desired substrate. We have attempted the sensors working on real human hand and proved them working properly.
Awards, Scholarships, Fellowships

2014 June 7th  Podium Presentation Awards at Canadian Biomaterials Society (CBS) conference in Halifax, Nova Scotia
2013 Dec. 6th  Best Teaching Assistant Nominee from Department of Mechanical Engineering in University of Victoria
2013 Aug. 5th  Korean Canadian Scientists’ Scholarship Foundation (KCSSF)
2013 April 4th  3rd and 4th Prizes in UTÝB TURKISH TEXTILE AND CLOTHING SECTOR INTERNATIONAL R&D BROKERAGE EVENT PROGRAMME
2012 – 2013  Fellowship, University of Victoria
2011 – 2012  Fellowship, University of Victoria
2009 – 2010  Fellowship, Graduate award, University of Victoria

Presentations


**Publications**


