



**University
of Victoria**

Graduate Studies

Notice of the Final Oral Examination
for the Degree of Master of Applied Science

of

VALÉRIE LOSIER

BSc (McGill University, 2015)

“Effect of Morphological Features of Fuel Cell Cathodes on Liquid Water Transport”

Department of Mechanical Engineering

Friday, May 12, 2017
1:45 P.M.
Engineering Office Wing
Room 106

Supervisory Committee:

Dr. Ned Djilali, Department of Mechanical Engineering, University of Victoria (Supervisor)
Dr. Caterina Valeo, Department of Mechanical Engineering, UVic (Member)

External Examiner:

Dr. Reuven Gordon, Department of Electrical and Computer Engineering, UVic

Chair of Oral Examination:

Dr. David Bristow, Department of Civil Engineering, UVic

Dr. David Capson, Dean, Faculty of Graduate Studies

Abstract

Liquid water management in the cathode of polymer electrolyte membrane fuel cells (PEMFC) is crucial to efficient transport of gases and to maintaining electrochemical activity in the catalyst layer. Cracks and interfacial voids are typical of catalyst layers in operating cells, and are thought to affect water management and other transport properties such as gas diffusion and conductivity. This thesis investigates the effect of such morphological imperfections on liquid water transport using a combination of numerical techniques. Both catalyst layer and microporous layer parts of the cathode are considered. The layers are first numerically reconstructed using data from advanced microscopy, and cracks, perforations and interfacial voids are created. Lattice Boltzmann simulations of the dynamics liquid water imbibition process are performed to study the effect of characterizing features of the cracks and interfacial voids such as aperture area, degree of protrusion, and tortuosity. The resulting liquid water distributions were then input into a pore scale model to characterize the effect of the morphological features on other transport properties, such as effective diffusivities and conductivities.

Larger crack apertures were found to increase liquid water uptake, and elongated cracks allowed for faster breakthrough and lower saturation levels. A notable observation is that short and large interfacial cracks have a higher liquid water uptake potential due to the lower effective capillary pressures. It was also found that elongated cracks aligned with the pressure gradient provide preferential pathway, and a capillary pressure increase that favours liquid water transport towards the membrane and mitigates flooding. The effective diffusivity increased for all crack protrusion depths, even for the wet catalyst layer, likely due to low liquid water saturation. The geometry with the most elongated crack showed a significant increase in gas diffusion under wet conditions, indicating enhanced gas transport is achievable when liquid water removal is effective. Protonic and electrical conductivities decreased for all crack shapes due to higher contact resistance.