

## **Publications**

1. J. F. Botero-Cadavid, A. G. Brolo, P. Wild, and N. Djilali, "Detection of hydrogen peroxide using an optical fiber-based sensing probe," *Sensors and Actuators B: Chemical*, vol. 185, pp. 166–173, Aug 2013. [Online]. Available: <http://dx.doi.org/10.1016/j.snb.2013.04.068>
2. —, "Fiber optic based sensor for H<sub>2</sub>O<sub>2</sub> detection in PEMFC's," in *5th International Conference Fundamentals & Development of Fuel Cells FDFC2013*. Karlsruhe, Germany: Karlsruhe Institute of Technology, April 2013.
3. H. A. Khorami, J. F. Botero-Cadavid, P. Wild, and N. Djilali, "Spectroscopic detection of hydrogen peroxide with an optical fiber probe using chemically deposited Prussian blue," *Electrochimica Acta*, vol. 115, pp. 416–424, 2014. [Online]. Available: <http://www.sciencedirect.com/science/article/pii/S0013468613021580>
4. J. F. Botero-Cadavid, P. Wild, and N. Djilali, "Temperature response and durability characterization of an optical fiber sensor for the detection of hydrogen peroxide," *Electrochimica Acta*, 2014. DOI: 10.1016/j.electacta.2014.02.088



University  
of Victoria

Graduate Studies

## **PROGRAMME**

The Final Oral Examination  
for the Degree of

DOCTOR OF PHILOSOPHY  
(Department of Mechanical Engineering)

**Juan F. Botero-Cadavid**

2007	National University of Colombia	MSc (Physics)
2004	National University of Colombia	BSc (Mech. Eng)

**"Fiber-Optic Sensor for Detection of Hydrogen Peroxide in PEM Fuel Cells"**

Wednesday, April 16, 2014  
10:00am  
Engineering Office Wing, room 108

### Supervisory Committee:

Dr. Nedjib Djilali, Department of Mechanical Engineering, UVic  
(Co-Supervisor)  
Dr. Peter Wild, Department of Mechanical Engineering, UVic  
(Co-Supervisor)  
Dr. Alexandre Brolo, Department of Chemistry, UVic (Non-Unit Member)

### External Examiner:

Dr. Sushanta Mitra, Department of Mechanical Engineering,  
University of Alberta

### Chair of Oral Examination:

Dr. Brian Thom, Department of Anthropology, UVic

## **Abstract**

This dissertation presents chemical sensors that are based on an emerging optical fiber sensing technology for the determination of the presence and concentration of hydrogen peroxide at low concentrations. The motivation to determine hydrogen peroxide lies on the fact that this chemical species is generated as a by-product of the operation of hydrogen-based polymer electrolyte membrane fuel cells (PEMFCs), and the presence and formation of this peroxide has been associated with the chemical degradation that results in low durability of PEMFCs. Currently, there are no techniques that allow the hydrogen peroxide to be determined *in situ* in PEMFCs in a reliable manner, since the only report of this type of measurement was performed using electrochemical techniques, which can be affected by the environmental conditions and that can alter the proper operation of the PEMFCs.

The sensors presented in this dissertation are designed to detect the presence and quantify hydrogen peroxide in solution at the conditions at which PEMFCs operate. Since they are made using fused silica optical fibers and are based on a spectroscopic technique to perform the detection of  $\text{H}_2\text{O}_2$ , they are not affected by the electromagnetic fields or the harsh chemical environment inside PEMFCs. In addition,

they are able to still detect the presence of  $\text{H}_2\text{O}_2$  at the operating temperatures.

The construction of the sensing film on the tip of an optical fiber and its small size (125  $\mu\text{m}$  diameter), make the sensors here developed an ideal solution for being deployed *in situ* in PEMFCs, ensuring that they would be minimally invasive and that the operation of the fuel cell would not be compromised by the presence of the sensor.

The sensors developed in this dissertation not only present design characteristics that are applicable to PEMFCs, they are also suitable for applications in other fields such as environmental, defense, and biological processes.

## **Awards, Scholarships, Fellowships**

2010 – In-course scholarship for outstanding academic performance, *University of Victoria*

## **Presentations**

1. Botero-Cadavid, Juan F.; Brolo Alexandre; Wild Peter; and Djilali, Ned. “Fiber optic based sensor for  $\text{H}_2\text{O}_2$  detection in PEMFCs” 5<sup>th</sup> International Conference on Fundamentals and Developments of Fuel Cells (FDFC2013), Karlsruhe, Germany, April 16<sup>th</sup>-18<sup>th</sup> (oral).