

# **Determination of Hydrogen Peroxide Concentration in Water-Hydrogen Peroxide Aerosols**

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**PhD Thesis**

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**2012**

## **Certificate of Authorship**

I certify that the work in this thesis has not previously been submitted for a degree, nor has it been submitted as part of requirements for a degree fully acknowledged within the text.

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## Acknowledgements

I would first like to express my sincere gratitude to my principle supervisor Prof. Michael Cortie for the opportunity to work on this project and the guidance he provided through it. I would also like to extend my sincerest thanks to my co-supervisor Dr. Matthew Arnold for his guidance and input throughout, including his assistance with the matrix algebra developed for the optical absorption measurements.

Funding and generous material support of this project was provided by Nanosonics Limited, and I am grateful to them for this and for providing data on droplet sizes of hydrogen peroxide produced by their nebuliser. Two individuals at Nansonics Limited, Dr. Galina Kouzmina and Mr. Brian Hingley, were key to the successful implementation of this project and I wish to specifically thank them for their involvement and assistance. Mr Hingley's deep knowledge of practical electronics was a major factor in this project as was Dr Kouzmina's chemical engineering expertise.

Several people at the University of Technology Sydney helped me during the course of this project. I would like to thank Mr. Geoff McCredie and Dr. Angus Gentle for their invaluable assistance with the RTD coating, Mr. Mark Berkahn and Dr. Annette Dowd for their invaluable assistance in obtaining X-ray diffraction patterns of my samples, Dr. Ric Wuhrer for his assistance in obtaining scanning electron microscope images, Dr. Catherine Kealley for her insights on the prospect of a monochromatic refractometric sensor, and Dr. Andrew McDonagh for general ideas and discussion. My fellow PhD students, particularly Michael Coutts, Jonathan Mak, Jonathon Edgar, Pew Supitcha and Amir Moezzi, have been supportive too, providing both an exchange of ideas and encouragement.

Finally, I would like to thank the Australian Synchrotron for access to the Powder Diffraction beamline at the Australian Synchrotron, Victoria, Australia.

At a personal level, I also wish to take this opportunity to sincerely thank my family for the support, encouragement and guidance that they have provided both in life and through my studies. My sincerest thanks to my mother Marie Anne, my father Boris, my

step-mother Susan, my grandparents Helen and Peter and my auntie Sonja and uncle Joe for all your support, encouragement and guidance in reaching this point.

## List of Publications Produced

A.J. Porkovich, M.D. Arnold, G. Kouzmina, B. Hingley, A.Dowd, M.B. Cortie, *Calorimetric sensor for use in hydrogen peroxide aqueous solutions*, Sensors Letters, **9** (2011) 695-697.

A.J. Porkovich, M.D. Arnold, G. Kouzmina, B. Hingley, M.B. Cortie, *Calorimetric Sensor for H<sub>2</sub>O<sub>2</sub>/H<sub>2</sub>O Mist Streams*, IEEE Sensors Journal, **12** (2012) 2392-2398.

C.S. Kealley, M.D. Arnold, A. Porkovich, M.B. Cortie, *Sensors based on monochromatic interrogation of a localised surface plasmon resonance*, Sensors and Actuators, B, **148** (2010) 34-40.

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## Abstract

This project focuses on the development of methods for evaluating the concentration of hydrogen peroxide in the mist streams used in a new generation of sterilisation technologies. This application presents unique experimental difficulties in that a sensor must be able to measure the concentration of hydrogen peroxide in a mist of droplets, and be able to do so in the concentration range between 30% and 40% (by percentage weight). Three separate methods of analysis were investigated.

A calorimetric sensor was constructed using a resistance temperature detector (RTD), coated with a heterogeneous catalyst, to measure the heat released after hydrogen peroxide is decomposed. Various ways of implementing this scheme were investigated, including immersion into fluid, dipping followed by drying, and using a heated RTD. The sensor was capable of determining concentrations from 0% to 40% (w/w) in both liquid hydrogen peroxide and aerosol hydrogen peroxide mixtures, with at best 4% and 3% (w/w) precision respectively. Surprisingly, the unheated sensor responded to hydrogen peroxide in the mist by undergoing a *decrease* in temperature. The physical phenomena responsible for this were investigated and explained. The heated RTD worked well as a sensor for mist density, however it was unable to determine concentration.

Three kinds of optically-based sensor were explored. It was determined by simulation that localised surface plasmon resonance using gold nanorods was the best way of developing a sensor based on refractive index. However, in the proof-of-concept experiments the gold nanorods were oxidised by hydrogen peroxide, making this sensor scheme unsuitable for this project. Absorbance spectroscopy was more successful, and was performed on two different path lengths of liquid hydrogen peroxide, analysed with a Fabry-Perot mid-infrared spectrometer. The concentration of liquid hydrogen peroxide could be determined in the range 0% to 27% (volume percentage), with best precision of 1% (v/v). To deal with multiple thicknesses of path length, a numerical technique using a matrix was developed to simultaneously determine concentration and thickness. Finally, some preliminary absorbance measurements of water mist were performed, which showed that, while scattering was significant, there is still a possibility of using this technique in an aerosol, to determine some measure of density. However, this last idea was not explored further here due to lack of time.