



NECEM SEMINAR: "Sono-Electrocatalysis : The Use of Sound for the Development of Water Electrolyser and Fuel Cell Electrocatalysts"

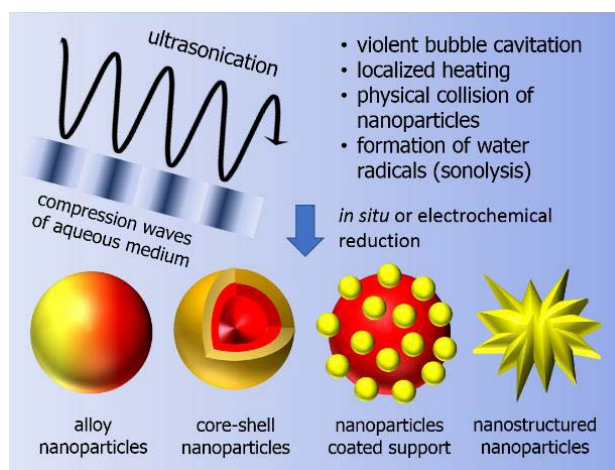
Prof. Bruno G. Pollet from

Norwegian University of Science and Technology (NTNU) in Trondheim

Wednesday 4th March 2020, 2-3pm

Newcastle University, Bedson Building, Lecture theatre 1.75

This presentation highlights some of the research works undertaken over the years by the *Pollet's* groups in *Birmingham*, *Cape Town* and *Trondheim* in the application of power ultrasound for the fabrication of electrolyser and fuel cell catalysts, electrodes and hydrogen production. The publication of 'The use of ultrasound for the fabrication of fuel cell materials' in the *International Journal of Hydrogen Energy* in 2010 [1] triggered an international interest in the use of power ultrasound (20 kHz – 1 MHz), sonochemistry (the use of ultrasound in chemistry) and



sonoelectrochemistry (the use of ultrasound in electrochemistry) [2-4] for the synthesis of energy materials and useful gases [5]. This is due to the fact that these techniques allow the generation of nano-energy materials of controlled sizes and shapes in a *one-pot* synthetic approach [6]. Furthermore, these methods do not require intensive labour as well as the use of large amounts of toxic and environmentally hazardous solvents that are often used in conventional chemical methods. In 2009, Zin, Pollet and Dabalà published the first paper in the literature highlighting the synthesis of platinum (Pt) nanoparticles from aqueous solutions using sonoelectrochemistry [7]. Recently, Karousos *et al.* [8] showed that Vulcan XC-72 carbon black (CB) substrate can be decorated with sonoelectrochemically produced Pt in a *one-pot-one-step* process by

combining galvanostatic pulsed electrodeposition and power ultrasound (20 kHz). In other studies, Pt and IrO₂ nanoparticles were synthesized sonoelectrochemically at room temperature in a three-electrode set up using an ultrasonicated working electrode or *sonoelectrode* generating very short applied current pulses (a few *ms*) triggered and followed immediately by short ultrasonic pulses (a few *ms* at 24kHz) [9,10]. Later on, Pollet *et al.* [11,12] showed that power ultrasound can be used for the *in-situ* fabrication of PEMFC electrodes [11] and Gas Diffusion Electrodes (GDEs) [11]. The electrodeposition of Pt on Gas Diffusion Layer (GDL) surfaces in dilute chloroplatinic acid solutions was performed potentiodynamically in the absence and presence of ultrasound (20kHz) at various ultrasonic powers. It was found that Pt electrodeposition required a substantial overpotential to drive the formation of Pt nuclei on GDL surfaces; however, under sonication, Pt electrodeposition became more facile due to lower concentration and nucleation overpotentials, and overall currents were significantly increased compared to *silent* conditions. It was also observed that the ECSA was improved for Pt/GDL electrodes prepared under sonication. In 2011, a research collaboration with *SonoTek Corporation (USA)* led to a novel ultrasonic-spray (US) method for preparing GDEs on various commercial woven and non-woven GDLs at several Pt loadings in the range of 0.40–0.05mg cm⁻² [13]. It was found that the GDEs prepared by the US method exhibited better performances compared to those prepared commercially, especially at low Pt loadings.

References

- [1] B.G. Pollet, The use of ultrasound for the fabrication of fuel cell materials, *Int. J. Hydrogen Energy* 22 (2010) 1039–1059.
- [2] B.G. Pollet, M. Ashokkumar, Introduction to Ultrasound, Sonochemistry and Sonoelectrochemistry; B.G. Pollet, M. Ashokkumar (Eds); SpringerBriefs: Berlin, Germany, 2019; ISBN 978-3-030-25862-7.
- [3] B.G. Pollet (Ed), Power ultrasound in electrochemistry: from versatile laboratory tool to engineering solution, John Wiley & Sons, Hoboken, NJ, USA (2012) ISBN: 978-0-470-97424-7.
- [4] B.G. Pollet, A short introduction to Sonoelectrochemistry. *Electrochem. Soc. Interface* 2018, 27, 41–4.
- [5] Md.H. Islam, O.S. Burheim, B.G. Pollet, Sono(electro)chemical Production of Hydrogen, *Ultras. Sonochem.* 51 (2019) 533–555.
- [6] M.T.Y. Paul, Md.H. Islam, O.S. Burheim, B.G. Pollet, Recent Development in Sonoelectrochemical Synthesis of Nanomaterials, *Ultrason. Sonochem.* 59 (2019) 104711–104715.
- [7] V. Zin, B.G. Pollet, M. Dabalà. Sonoelectrochemical (20kHz) production of platinum nanoparticles from aqueous solutions. *Electrochim. Acta* 54(28) 20097201–7206.
- [8] D.S. Karousos, K.I. Desdenakis, P.M. Sakkas, G. Sourkouni, B.G. Pollet, C. Argiris. Sonoelectrochemical one-pot synthesis of Pt–Carbon black nanocomposite PEMFC electrocatalyst. *Ultrason. Sonochem.* 35(B) (2017) 591–597.
- [9] C. Felix, B.J. Bladergroen, V. Linkov, B.G. Pollet, S. Pasupathi, Ex-situ electrochemical characterization of IrO₂ synthesized by a modified Adams Fusion method for the oxygen evolution reaction, *Catalysts* 2019, 9, 318; doi:10.3390/catal9040318.
- [10] B.G. Pollet, The use of power ultrasound for the production of PEMFC and PEMWE catalysts and low-Pt Loading and high-performing electrodes, *Catalysts* 9(3), 246–250.
- [11] B.G. Pollet, A novel method for preparing PEMFC electrodes by the ultrasonic and sonoelectrochemical techniques. *Electrochem. Comm.* 11(7) (2009) 1445–1448.
- [12] B.G. Pollet, E.F. Valzer, O.J. Curnick. Platinum sonoelectrodeposition on glassy carbon and gas diffusion layer electrodes. *Int. J. Hydrogen Energy* 36(10) (2011) 6248–6258.
- [13] B. Millington, V. Whipple, B.G. Pollet. A novel method for preparing proton exchange membrane fuel cell electrodes by the ultrasonic-spray technique 196(20) (2011) *J. Power Sources* 8500–8508.

Biography



Bruno G. Pollet (Google Scholar *h*-index = 38) is a full Professor of Renewable Energy at the Norwegian University of Science and Technology (NTNU) in Trondheim. He currently leads the "NTNU Team Hydrogen". He is a *Fellow of the Royal Society of Chemistry* (RSC, UK), an *Associate Fellow of the Institution of Chemical Engineers* (IChemE, UK) and Board of Directors' member of the *International Association for Hydrogen Energy* (IAHE). He is Visiting Professors (VP) at the University of Ulster (UK) and the University of the Western Cape (RSA), and was a VP at the University of Yamanashi, Professor Watanabe's labs

(Japan). His research covers a wide range of areas in Electrochemistry, Electrochemical Engineering, Electrochemical Energy Conversion and Sono-electrochemistry (Power Ultrasound in Electrochemistry) from the development of novel hydrogen & fuel cell materials, CO₂ conversion, to water treatment/disinfection demonstrators & prototypes. He was a full Professor of Energy Materials and Systems at the University of the Western Cape (RSA) and R&D Director of the National Hydrogen South Africa (HySA) Systems Competence Centre. He was also a Research Fellow and Lecturer in Chemical Engineering at The University of Birmingham (UK) as well as a co-founder and an Associate Director of The University of Birmingham Centre for Hydrogen and Fuel Cell Research. He has worked for Johnson Matthey Fuel Cells Ltd (UK) and other various industries worldwide as Technical Account Manager, Project Manager, Research Manager, R&D Director, Head of R&D and Chief Technology Officer. He was awarded a Diploma in Chemistry and Material Sciences from the Université Joseph Fourier (Grenoble, France), a BSc (Hons) in Applied Chemistry from Coventry University (UK) and an MSc in Analytical Chemistry from The University of Aberdeen (UK). He also gained his PhD in Physical Chemistry in the field of Electrochemistry and Sonochemistry under the supervision of Professors J. Phil Lorimer & Tim J. Mason at the Sonochemistry Centre of Excellence, Coventry University. He undertook his PostDoc in Electrocatalysis at the Liverpool University Electrochemistry group led by Professor David J. Schiffrin. Bruno has published many scientific publications, articles, book chapters and books in the field of Sonoelectrochemistry, Fuel Cells, Electrocatalysis and Electrochemical Engineering. Bruno is member of several editorial boards of international journals (Elsevier, Springer and Wiley). He is also fluent in English, French and Spanish.

https://no.wikipedia.org/wiki/Bruno_Georges_Pollet

Location

Newcastle University, Bedson Building, Lecture theatre 1.75

Refreshments available after the seminar from 3pm in the Faraday Room. Bedson building, Newcastle University

