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# EPFL Valais/Wallis SEMINAR

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## High performance direct borohydride fuel cell using non-PGM electrocatalysts

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The Direct Borohydride Fuel Cell (DBFC) is being investigated for several years as a potential power generator technology for portable and mobile applications. It takes advantage of the high intrinsic energy density of the borohydride fuel: the Borohydride Oxidation Reaction (BOR), that occurs at the anode can theoretically provide 8 electrons and has a really low theoretical onset potential of -0.42 V *vs* RHE. Although Pt-group metal (PGMs) catalysts are the benchmarks for this reaction, they are severely limited by the competition of the desired BOR with the unwanted hydrogen evolution reaction (HER) at potential below 0 V *vs* RHE, a potential window which is desired for the application if one wants to optimize the potential efficiency of the fuel conversion. In order to limit this competition, one should consider a catalyst with a poor HER activity. In this regard, carbon-supported Ni electrodeposited nanoparticles showed impressive performance at low potentials but more limited at higher potentials [1]. Such performance has been obtained by precisely controlling the state of the nickel surface, as described by Oshchepkov *et al.* [1], [2]. This catalyst has been used in a single cell configuration and promising results were obtained [1].
In order to increase even more the performance of the cell, Ni-foam structures have been employed to obtain highly porous and totally metallic (nickel) anodes. This new electrode morphology allowed to reach performance competing with that of Pt electrodes above 0 V *vs* RHE (and surpassing Pt below this value). Another aspect limiting the performance of the DBFC is the use of inappropriate membranes, such as commercial Nafion 212 (in $Na^+$ form). The group of Ramani developed a bipolar interface allowing to maintain highly different pH at the anode and the cathode, which drastically improves the performance of the system [3]. The fully-nickel-based anodes presented earlier have been used with such interfaces and performance greatly surpassing noble-based electrodes has been obtained [4]. Fully non-noble cells using Fe-N-C catalysts (from the group of Jaouen) at the cathode have also been tested and presented interesting results, given that the cell is 100% PGM free, when used in conjunction with an anion-exchange membrane.

References:

[1] A. G. Oshchepkov *et al.*, "Nickel Metal Nanoparticles as Anode Electrocatalysts for Highly Efficient Direct Borohydride Fuel Cells," *ACS Catal.*, vol. 9, no. 9, pp. 8520–8528, Aug. 2019.
[2] A. G. Oshchepkov, G. Braesch, A. Bonnefont, E. R. Savinova, and M. Chatenet, "Recent advances in the understanding of Ni-based catalysts for the oxidation of hydrogen-containing fuels in alkaline media," *ACS Catal.*, p. acscatal.0c00101, May 2020.
[3] Z. Wang, J. Parrondo, C. He, S. Sankarasubramanian, and V. Ramani, "Efficient pH-gradient-enabled microscale bipolar interfaces in direct borohydride fuel cells," *Nat. Energy*, vol. 4, no. 4, pp. 281–289, 2019.
[4] G. Braesch *et al.*, "A high performance direct borohydride fuel cell using bipolar interfaces and noble metal-free Ni-based anodes," *J. Mater. Chem. A*, vol. 8, no. 39, 2020.

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Born in 1994 in Annecy, France, Guillaume Braesch graduated with a Bachelor Degree in Physics and Chemistry from the University of Savoie-Mont Blanc in 2015. He then specialized himself by graduating with a Master degree in Electrochemistry and Processes from Grenoble-INP in 2017. He went on to pursue graduate studies in University Grenoble-Alpes and obtained his PhD degree in 2020. His doctoral work focused on electrocatalysts for the borohydride oxidation reaction for alkaline fuel cells and especially, going from model noble surfaces towards non-noble fuel cell anodes. He is now a post-doctoral fellow working on oxygen reduction and hydrogen oxidation reactions on platinum group metal-based catalysts at University Grenoble-Alpes. He will soon join CEA-Grenoble to work, as an R&D engineer on, on fuel cells.