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Report on the PhD Thesis manuscript submitted by M. Roman Fiala,

"Investigation of new catalysts for polymer membrane fuel cells", Charles University

Innovative systems for energy conversion such as fuel cells are required for powering small devices or for mobile and stationary applications. The usual electrode materials in Polymer Membrane Fuel Cell (PEMFC) are composed of platinum-based materials. For decreasing their cost, a drastic decrease of the platinum loading is essential. Moreover, this Pt loading has to be combined with the increase of active sites able to give very high performance and durability. M. Roman Fiala submitted a PhD thesis entitled "*Investigation of new catalysts for polymer membrane fuel cells"*, which deals with this hot topic. Indeed, he has investigated a new class of electrocatalysts for PEMFC.

The PhD Thesis manuscript of M. Roman Fiala contents four main parts including the introduction and the conclusion.

The introduction and the theory chapters concern the fundamental aspects of PEMFC. These two first chapters expose extensively the basic, challenges and the main targets of the thesis.

The second important part (experimental section) describes the materials fabrication, the electrochemical techniques (cyclic voltammetry, electrochemical impedance spectroscopy), the microscopy observations (by SEM and TEM) and the test protocol. A new cell design and the automatized test station were presented. M. Roman Fiala used the rf-magnetron sputtering deposition method for fabricating the catalytic layer on GDL.

The major part of the PhD thesis is the chapter on experimental results. M. Roman Fiala shows the performance of the cell using PtO_x as an anode catalytic layer. It appears that this catalytic layer leads to a higher power density compared to the pure platinum. The XPS surface characterization of the PtO_x layer used as anode material, reveals the role of the H_2 exposure on this oxide film.

Several interesting materials were elaborated and used in this thesis. One of them is the ceria supported platinum film (Pt-CeO_2). Different Pt loadings were prepared. The spectacular result was obtained with 2 µg cm^{-2} of Pt on ceria (anode material). The result obtained with

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this catalytic layer showed that the same performance can almost be reached by dividing the Pt loading by 1000 in comparison with the conventional 2 mg cm^{-2} Pt electrode.

The sputtered cathode materials made of PtCo were fabricated and tested in the fuel cell conditions using conventional Pt anode. The sputtered cathode exhibited excellent performance toward the oxygen reduction reaction. Combining these two thin films as catalytic layers at the electrodes, the results obtained by Roman Fiala, are promising for fuel cell development. The performance of other materials such as Pt-$SnCeO_x$, Pd-CeO_x was also evaluated as well as the substitution of CeO_x by WO_x. Moreover, complementary investigations on the durability of the catalysts and their tolerance towards the CO were also performed. The utilization of the XPS and then NEXAFS (in situ or in operando mode) permitted to reveal the cationic state of the metal (Pt or Pd) and the partially reduced state of the ceria.

Overall, M. Roman Fiala has performed an original and very interesting research for his PhD project. The thesis is well written and easy to follow. The interpretation of the results is rigorous. M. Roman Fiala draws conclusions that are supported by experimental results. The manuscript demonstrates that M. Roman Fiala well understands the challenges in fuel cell.

Based on my evaluation, the manuscript of M. Roman Fiala meets all the requirements for a PhD thesis of the Charles University.

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