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To cite this article: Eneli Härk et al 2012 Meet. Abstr. MA2012-01 1481

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## Impact of the various catalysts (Pt, Pt-Ru) deposited onto carbon support to the slow oxygen reduction reaction kinetics

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The slow oxygen reduction reaction (ORR) kinetics on Pt and/or PtRu catalysts is one of the most limiting factors in the energy conversion efficiency of the PEMFC. Alternative materials are therefore highly sought for fuel cell applications. Improved cathode catalysts would have a dramatic impact on the fuel cell efficiency [1-4]. During long lasting catalysts optimization studies various carbon supports have been used [5-9]. The main aim of this work was to compare various catalysts combinations deposited onto the micromesoporous carbon support prepared from WC [10] and to analyze oxygen electroreduction kinetics in 0.5 M H<sub>2</sub>SO<sub>4</sub> solution. Pt or binary PtRu catalyst was deposited onto micromesoporous carbon support C(WC) with specific surface area 1280 m<sup>2</sup>g<sup>-1</sup> and 1580 m<sup>2</sup>g<sup>-1</sup>, prepared from WC at 1000°C and 1100°C using chlorination synthesis method [10]. According to analysis of XRD, XRF, XPS and SEM-EDX data the ratio of Pt Ru was 50:50 at%. CV and RDE data show that high cathodic O2 electroreduction current densities have been achieved for the Pt-Ru-C(WC)|GCDE electrode studied (GCDE - glassy carbon disk electrode) (Fig.1). The minimum in j,E - curves at E=-0.4V indicates, that the formation of H2O2 takes place at Pt-Ru-C(WC)|GCDE electrode. This is in a good agreement with impedance data indicating to the adsorption step limited faradaic reaction mechanism. Analysis of impedance spectra show that at E = -0.5 V (vs MSE) the very high series and parallel capacitance values ~1.43 F·cm<sup>-2</sup> have been established for the Pt-Ru-C(WC 1100°C)|GCDE electrode studied (Fig.2). For all electrode potentials coincide of series and parallel capacitance values at ac fregrency f < 0.05 Hz has been observed. Analysis of impedance spectra show that ideal capacitive behavior at very low ac frequency region has been observed for C(WC) electrodes, where the O<sub>2</sub> reduction reaction rate is limited by the rate of adsorption step. The phase angle value nearly  $\theta \ge -87^\circ$  at f < 1 Hz can be seen, explained by the adsorption step limited faradic pseudocapacitive processes at micromesoporous C(WC) electrodes in H<sub>2</sub>SO<sub>4</sub> aqueous solution (Fig.3). Thus, Pt-Ru-C(WC) catalysts are interesting electrode materials for polymer electrolyte and hybrid supercapacitor systems.



Fig. 1. RDE data for C(WC) 1000 °C and Pt-Ru-C(WC) 1000 °C electrodes, prepared from corresponding inks and deposited onto GCDE, for ORR in 0.5 M H<sub>2</sub>SO<sub>4</sub> solution

saturated with O<sub>2</sub>, at rotation velocities (0, 500, 800, 1000, 1500, 2000, 2500 and 3000 rev min<sup>-1</sup>) at potential scan rate ( $\nu = 10 \text{ mV sec}^{-1}$ ) (data uncorrected for current densities in Ar saturated 0.5 M H<sub>2</sub>SO<sub>4</sub> solution).



**Fig.2.** *Cs*, log *f*- (filled marks) and *Cp*, log *f*-plots (unfilled marks) for various C(WC)|GCDE systems (noted in figure) in 0.5 M H<sub>2</sub>SO<sub>4</sub> solution, saturated with O<sub>2</sub>, at *E* = -0.5V.



**Fig.3.** Bode phase angle  $-\theta$ , log *f*- plots for various electrodes studied (noted in figures) in 0.5 M H<sub>2</sub>SO solution, saturated with O<sub>2</sub> (at different *E*, noted in figure).

Acknowledgements: This work was supported by Estonian target research project SF0180002s08 and Grant ETF8267. Authors thank J.Eskusson for performing SEM-EDX and XPS measurements and analysis of data.

## References

- [1] B. Wang, J. of Power Sources 152 (2005) 1.
- [2] O.A. Petrii, J. Solid State Electrochem 12 (2008) 609.
- [3] T.J. Shmidt, H.A. Gasteiger, G.D. Stäb, P.M. Urban, D.M. Kolb and R.J. Behm, J. Electrochem. Soc 145(1998) 2354.
- [4] T.J. Shmidt, H.A. Gasteiger, and R.J. Behm, J. Electrochem. Soc 146 (1999) 1296.
- [5] G.S. Chai, S.B. Yoon, J.-S. Yu, J.-H.Choi, Y.-E. Sung, J. Phys. Chem. B 108 (2004) 7074.

[6] S. Gottesfeld, I.D. Raistrick, S. Srinivasan, J. Electrochem. Soc 134 (1987) 1455.

[7] E. Antolini, Applied Catalysis B Environmental 88 (2009) 1.

[8] A. Jänes, T. Thomberg, E. Lust, Carbon 45 (2007) 2717.

[9] G. Álvarez, F. Alcaide, O. Miguel, L. Calvillo, M. J. Lázaro, J. J. Quintana, J. C. Calderón, E. Pastor, J. Solid State Electrochem 14 (2010) 1027.

[10] I. Tallo, T. Thomberg, A. Jänes, K. Kontturi, E. Lust, Carbon, 49 (2011) 4427.