

Surface characteristics and advanced electrocatalytic properties of oxophilic metal modified rutile composite supported platinum electrocatalysts

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For the wide-range implementation of polymer electrolyte membrane (PEM) fuel cells, it is most essential to produce low-cost durable units. As the currently used Pt/C electrocatalysts are responsible for 30-40% of the price of the PEM fuel cells, intense research is focused on either replacing Pt with cheaper alternatives or decreasing the Pt load while enhancing the activity and longevity of the catalysts by suitable modification of the support. In our previous studies this concept was realized by synthesizing Pt electrocatalysts supported on a conductive and corrosion resistant composite consisting of oxophilic metal M (M: W, Mo)-doped TiO₂ and various carbonaceous materials [1-2]. In these multifunctional supports the carbon backbone is responsible for the high surface area and electrical conductivity, the TiO₂ component helps in stabilizing the Pt in highly dispersed state thus offering resistance against electrocorrosion, while the dopant metal cations incorporated into the titania improve the conductivity and provide valuable co-catalytic function, thus the composite supports can mitigate the known drawbacks of the current state-of-art Pt/C systems [1-2]. The transition metal dopant facilitates the oxidation of CO at much lower potentials than on pure Pt, which is important when hydrogen from steam reforming is considered as fuel [3]. The aim of the present work is the study of Ti_(1-x)M_xO₂-C (M: Mo, Sn; x: 0.1-0.3) composite supported Pt electrocatalysts. In this contribution, our efforts were aimed at elucidating the effect of (i) the type of carbonaceous materials, (ii) the mixed oxide/carbon ratio and (iii) the nature of active M-Pt assemblies in mixed oxide-carbon composite supports on the electrocatalytic performance of related Pt catalysts.

The technique previously developed by our research group for Ti-Mo mixed oxide-carbon composite materials [2-3] was adapted for the preparation of tin-containing composites of various compositions. We demonstrated that the composites and Pt electrocatalysts prepared by this modified synthesis route were free of segregated Sn⁰ or SnO₂ phases, possessed a more homogeneous/uniform mixed oxide distribution, and the ECSA values were comparable to those obtained on Mo-based composites of similar composition (~60-80 m²/g_{Pt}). Comparison of Mo- and Sn-containing 20 wt.% Pt/Ti_{0.8}Mo_{0.2}O₂-C electrocatalysts with a high carbon content (75 wt.%) revealed that the Sn-containing catalysts can be not

only promising CO-tolerant anode but also cathode catalysts for potential use in PEM fuel cells.

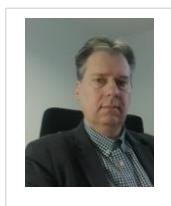
We proved that during the reductive pretreatment of the Mo-containing catalysts, ionic Mo formations appear on the Pt particles, which increases their stability [4-5]. *In situ* XPS study of the effect of reductive treatments of Sn-containing electrocatalysts showed that this treatment induces Sn-Pt alloying. During oxidative treatment, the alloyed particles are encapsulated by a layer of SnO_x layer, but this encapsulation is reversible by repeated reduction.

Integration of novel catalysts into membrane electrode assemblies (MEAs) and building of PEM fuel cells and stacks from these MEAs for performance tests under laboratory conditions and for application in new hydrogen powered electronic devices will be demonstrated in the lecture.

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References

- [1] D. Gubán, I. Borbáth, Z. Pászti, I. E. Sajó, E. Drotár, M. Hegedűs, A. Tompos *Appl. Catal. B: Environ.*, 174 (2015) 455-470.
- [2] I. Borbáth, E. Tálás, Z. Pászti, K. Zelenka, I. Ayyubov, K. Salmanzade, I. E. Sajó, Gy. Sáfrán, A. Tompos *Appl. Catal. A: Gen.*, 620 (2021) 118155.
- [3] M. S. Yazici, S. Dursun, I. Borbáth, A. Tompos, *Int. J. Hydrogen Energy*, 46 (2021) 13524-13533.
- [4] D. Diczházi, I. Borbáth, I. Bakos, G. Szijjártó, A. Tompos, *Z. Pászti Catal. Today*, 366 (2021) 31-40.
- [5] C. Silva, I. Borbáth, K. Zelenka, I. E. Sajó, G. Sáfrán, A. Tompos, Z. Pászti, *React. Kinet. Mech. Catal.*, 135 (2022) 29-47.



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