THE EFFECT OF HETEROATOM-DOPED GRAPHENE SUPPORTS ON PtNPs ELECTROCATALYTIC ACTIVITY FOR ORR

Raegan Chambers, Heiki Erikson and Kaido Tammeveski
Institute of Chemistry, University of Tartu, 50411 Tartu, Estonia
raegan.danielle.chambers@ut.ee

Global energy consumption along with the negative impacts of fossil fuels have led to an emphasis on the production of renewable energy. One source that can help to decrease the demand of fossil fuels are low-temperature fuel cells, including both proton-exchange membrane fuel cells (PEMFCs) and anion-exchange membrane fuel cells (AEMFCs). To optimize efficiency of both the cathode and anode, fuel cells use a Pt-based catalyst, which has a robust performance in alkaline and acidic environments.[1,2] Economic viability and surface poisoning are quite severe drawbacks of using Pt-based catalysts.[1] Platinum nanoparticles (PtNPs) loaded onto graphene support can be used to help mitigate some of the drawbacks associated with Pt-based catalysts.[3]

To maximize the electrocatalytic activity, the support material that the PtNPs are loaded onto must be optimized. During this study the effect of different commercially available heteroatom-doped graphene supports on the oxygen reduction reaction (ORR) activity of PtNPs was analyzed. PtNPs of less than 5 nm in size were synthesized using the citrate method. In respect to the Vulcan XC-72R carbon, which was used as the comparison the commercially available heteroatom-doped graphene performed differently in the ORR process and in half-wave potentials ($E_{1/2}$). The PtNPs deposited on nitrogen-doped graphene (Pt/N-C), sulfur-doped graphene (Pt/S-C) and nitrogen/sulfur-doped graphene (Pt/NS-C) showed improvements over the Pt/C with an $E_{1/2}$ value of 0.86 V (Pt/N-C), 0.86 V (Pt/S-C) and 0.81 V (Pt/NS-C) vs. RHE as compared to the 0.76 V of the Pt/C. The Tafel slopes of -60 mV per decade confirmed that the transfer of the first electron was the rate-determining step for all catalysts as proved in literature of Pt supported on different carbons[2]. This study confirmed that the support material used for the loading of PtNPs does have an effect on the electrocatalytic activity.

References:

(1) Holton, O. T.; Stevenson, J. W. The Role of Platinum in Proton Exchange Membrane Fuel Cells. *Platin. Met. Rev.* **2013**, *57* (4), 259–271. https://doi.org/10.1595/147106713X671222.
(2) Hussain, S.; Erikson, H.; Kongi, N.; Sarapuu, A.; Solla-Gullón, J.; Maia, G.; Kannan, A. M.; Alonso-Vante, N.; Tammeveski, K. Oxygen Reduction Reaction on Nanostructured Pt-Based Electrocatalysts: A Review. *Int. J. Hydrog. Energy* **2020**, *45* (56), 31775–31797. https://doi.org/10.1016/j.ijhydene.2020.08.215.
(3) Jukk, K.; Kongi, N.; Rauwel, P.; Matisen, L.; Tammeveski, K. Platinum Nanoparticles Supported on Nitrogen-Doped Graphene Nanosheets as Electrocatalysts for Oxygen Reduction Reaction. *Electrocatalysis* **2016**, *7* (5), 428–440. https://doi.org/10.1007/s12678-016-0322-1.

Euroopa Liit
Euroopa
Regionaalarengu Fond

Eesti
tuleviku heaks