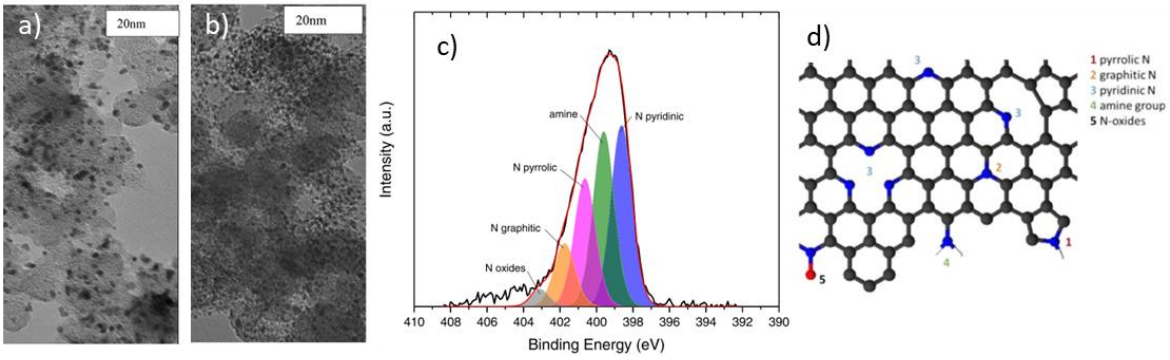
M.Sc. Thesis Opportunity: Date: November/2023

Plasma Activation of Carbon Black as Support Material for Engineered Platinum Catalysts

Background & Motivation

A key issue of the ongoing energy transition is usage and/or storage of excess electricity from fluctuating renewable sources. At the same time, many substances that today are derived from petrochemical sources must soon be replaced in order to achieve net zero carbon dioxide emission. Power-2-X technology addresses both of these issues. A prime example is electrochemical water splitting through, e.g., PEM electrolysis, now being rolled out commercially on the 100 MW scale. A major obstacle to the steep growth in electrolyser manufacturing output is cost and limited supply of Platinum (Pt) catalysts and other Platinum group metal (PGM). Hence, Pt is used sparsely in the form of finely dispersed particles on a host material, e.g. Pt-loaded carbon (Pt/C, figure a, b)[1], through wet impregnation or alternative nanofabrication methods.



The Project

However, the frequently used carbon black host material tends to be rather inert: Pt is deposited only at defects and hence the density of active Pt particles is limited. It has been shown that pre-treating the samples in an oxygen or nitrogen plasma can greatly increase the number of nucleation sites (figure c, d)[2]. For this Master's project, we are aiming for a similar activation of carbon black powder using a surfatron plasma source prior to Pt deposition with our fabrication method. Major steps within the project are:

- Extending/Improving an existing experimental setup for plasma exposure of carbon black. This will include hands-on lab work, as well as engineering challenges along the way.
- Experiments on plasma activation of carbon powder and evaluation via appropriate methods (e.g. XPS)
- If time permits, deposition of Pt and investigation of particle dispersion and morphology.

You will be part of a larger project that includes theoretical work, as well as further experimental parts up to the demonstration of advanced Pt/C catalysts in real-world applications (e.g., in a PEM setup). We are looking for students with an interest in experimental work, catalysts and the energy transition from various disciplines.

Interested?

Contact us at p.m.piechulla@tudelft.nl for more information! The project will be supervised by dr. Peter Piechulla, dr. Atul Bansode, and prof. dr. Ruud van Ommen (PPE/ChemE/TNW and e-refinery).

References

(1) Loganathan, K.; Bose, D.; Weinkauf, D. Surface Modification of Carbon Black by Nitrogen and Allylamine Plasma Treatment for Fuel Cell Electrocatalyst. *International Journal of Hydrogen Energy* **2014**, *39* (28), 15766–15771. https://doi.org/10.1016/j.ijhydene.2014.07.125.

(2) Parnière, A.; Blanchard, P.-Y.; Cavaliere, S.; Donzel, N.; Prelot, B.; Rozière, J.; Jones, D. J. Nitrogen Plasma Modified Carbons for PEMFC with Increased Interaction with Catalyst and Ionomer. *J. Electrochem. Soc.* **2022**, *169* (4), 044502. https://doi.org/10.1149/1945-7111/ac609e.