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# 3D graphene-based material as catalyst support material for fuel cells

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## Introduction

The combination of electrolyzers and fuel cells is a logical candidate for the much needed energy storage resulting from the use of modern renewable energy sources. A classical electrode material used in these applications is platinum supported on carbon.

The carbon support used in these applications needs to have a large electrochemical available surface area and be very electrochemically redox stable. Therefore materials developed for supercapacitors could also be interesting candidates for these applications because they possess these characteristics. A good candidate could be the high performance 3D graphene-based materials because of their extremely high surface area and good electrochemical stability.

## Synthesis of 3D graphene-based carbon supports

Porous three-dimensional graphene based carbon nanostructures were prepared via in-situ hydrothermal polymerization and carbonization followed by chemical activation and graphitization. In this process, which was initially developed for preparation of electrode materials for supercapacitors [1], an aqueous suspension of hummers graphite oxide was mixed with an organic precursor and heated in a sealed Teflon lined autoclave at 180 °C for 12 hours. The resulting product was washed with ultrapure water and dried in vacuum. Then it was mixed and ground together with potassium hydroxide and activated in a tube furnace in an argon atmosphere at temperature in the range of 800-900 °C. After activation the material was washed with a dilute hydrochloride solution followed by ultrapure water until a pH value of 7 was achieved. Finally the now activated carbon material was dried in vacuum.

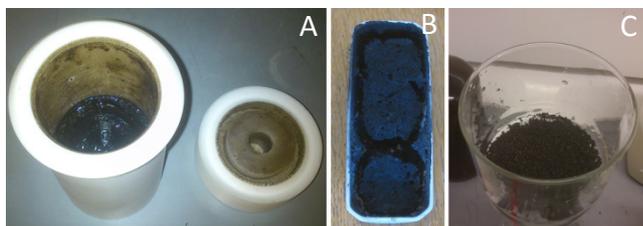


Figure 1 – Pictures from the different synthesis steps: A) Hydrothermal synthesis; B) Activation; C) Purification.

## Platinization

Platinization of the 3D graphene-based materials were tried using a modified polyol method. The platinum content was later determined by oxidation of the materials in 5 % oxygen in a TG. It was found that no platinum had precipitated in the sucrose based material and only 3 w% platinum was found in the phenolic resin based material.

## Characterization

The phenolic resin based material with 3 w% platinum was characterized using cyclic voltammetry in 0.5 M HClO<sub>4</sub>. The active material was mixed with 20 w% Nafion® and 3 w% PVP and suspended in water/ethanol using ultrasound. This suspension was used to coat a 5 mm GC electrode to give a total platinum loading of 1.86 μg on the electrode surface.

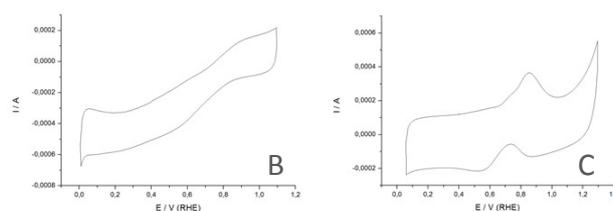
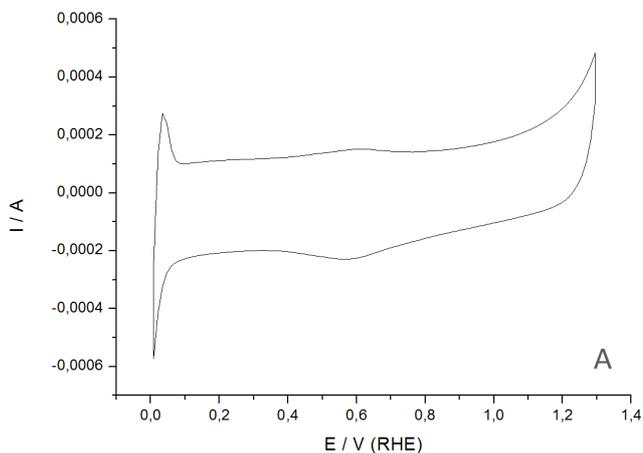


Figure 2 – Cyclic voltammograms recorded using a scan rate of 10 mV/s: A) Hydrogen formation; B) ORR at 1600 rpm; C) Methanol oxidation with 1 M methanol.

## Conclusion

Carbon materials with very high specific electrochemically available surface areas can be made by hydrothermal synthesis based on graphene oxide followed by chemical activation. More work is needed on the optimization of the platinization of these materials. With only 3 w% they show clear catalytic activity but still far from catalyst with high platinum content.

### Reference

[1] Zhang, L., Zhang, F., Yang, X., Long, G., Wu, Y., Zhang, T., ... Chen, Y. (2013). Porous 3D graphene-based bulk materials with exceptional high surface area and excellent conductivity for supercapacitors. *Scientific Reports*, 3, 1408. doi:10.1038/srep01408