Technical University of Denmark

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Chemical Production of Graphene Catalysts for Electrochemical Energy Conversion

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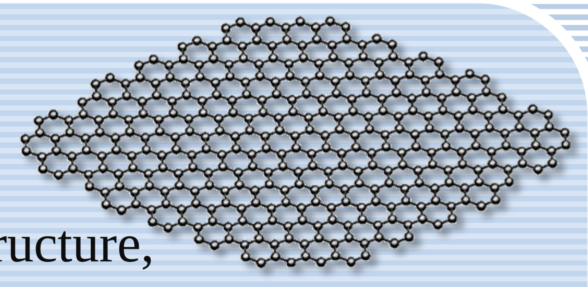
Project purposes

Development of (1) graphene catalysts with high activity at low cost and pursuing their application in fuel cells, and (2) new catalysts with low Pt loading. The project will specifically address:

- chemical synthesis procedures to produce graphene nanosheets,
- production of graphene 3D structures as a support for Pt with a view on electrochemical energy conversion,
- testing of the catalyst in fuel cells.

Shape- and size-controlled catalysts such as nanosheets and core-shell metallic nanostructures will be synthesized with the expensive catalytic element Pt on the surface of composite nanostructures.

Graphene



- Unique atom-thick two-dimensional (2D) structure,
- high conductivity and optical transparency,
- large specific surface area for loading catalysts,
- excellent mechanical, thermal and electrical properties.

Graphene is regarded as an important component for functional materials, especially for developing a variety of catalysts.

Platinum catalyst

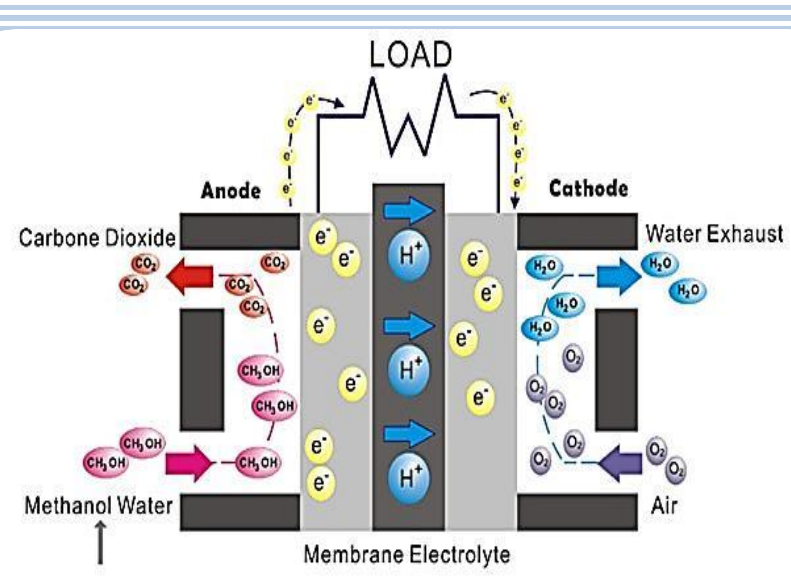
Pt is presently one of the most efficient fuel cell catalysts. However, the price of Pt is rocketing and new catalysts with low Pt load are imperative.

Pt will be synthesised in the form of nanoparticles, which assures:

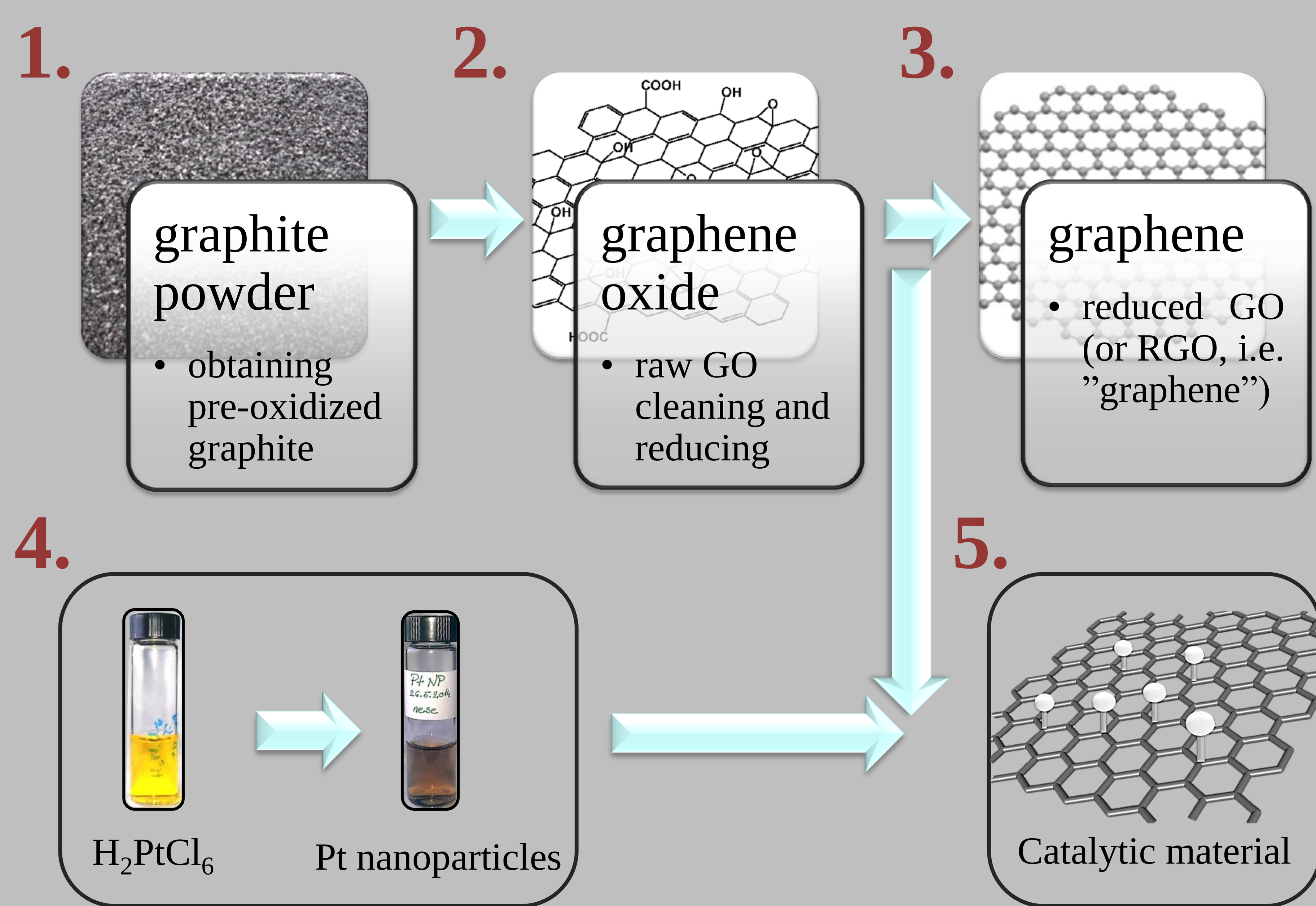
- better surface coverage of the catalyst on the support (graphene),
- better stability (towards platinum poisoning),
- higher efficiency compared to bulk platinum material,
- lower price of the applied fuel cell since less Pt is required due to scaling down to nano level.

Direct-methanol fuel cells (DMFC)

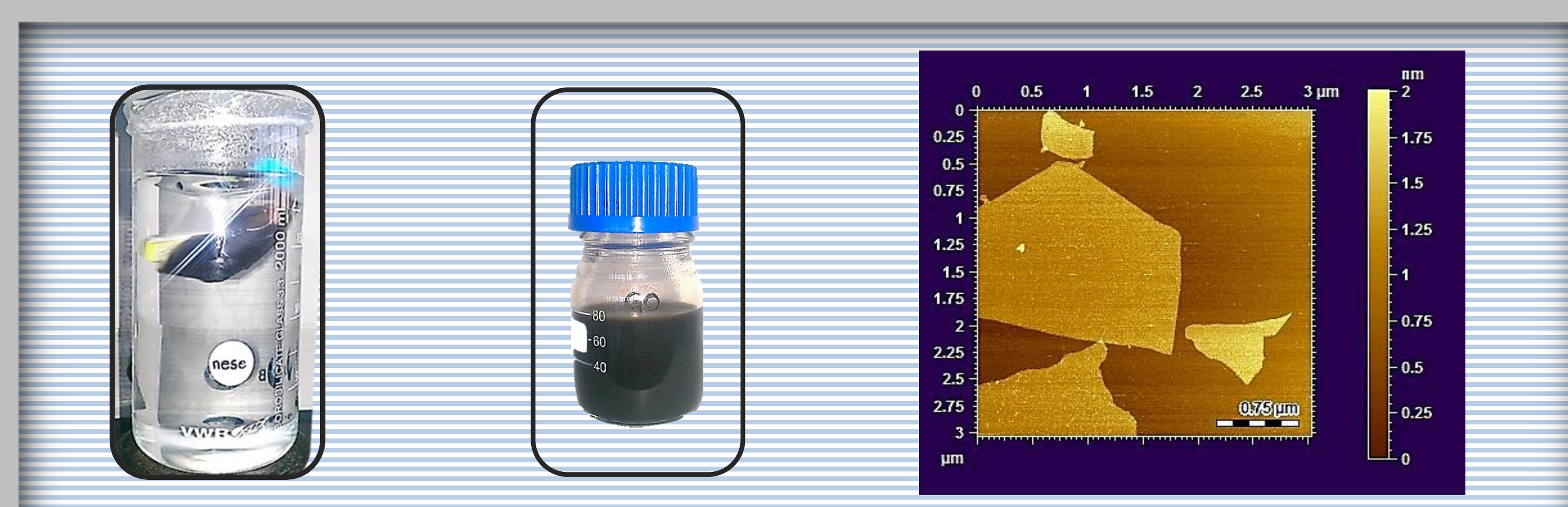
- ease of transport,
- energy-dense,
- stable fuel under environmental conditions,
- targeted to portable applications.



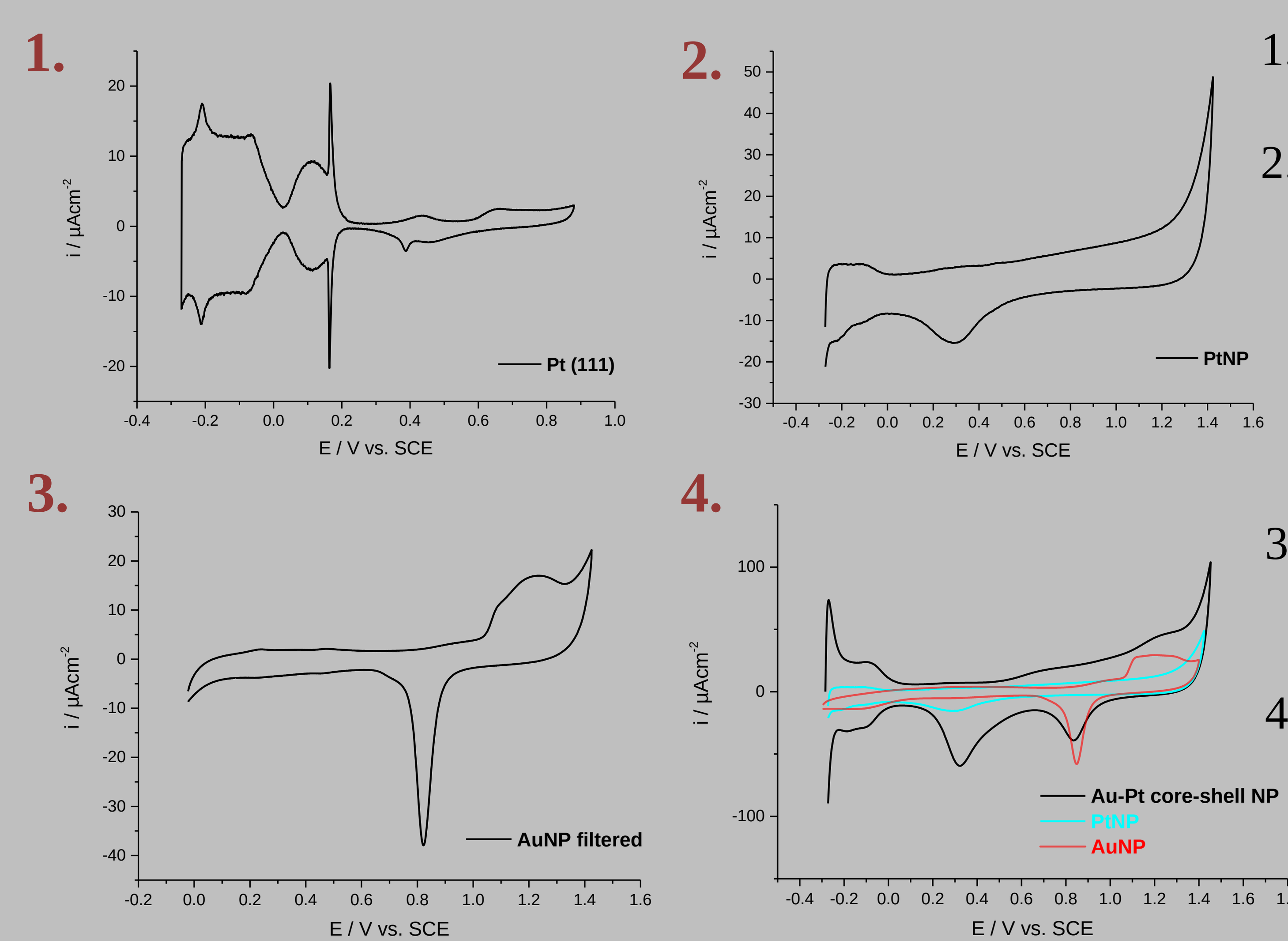
Chemical synthesis of graphene



Chemical synthesis of graphene uses graphite powder as a raw material. Graphene is obtained by further reduction of GO.



Dialysis of GO; synthesised GO; AFM image of GO sheet on mica.



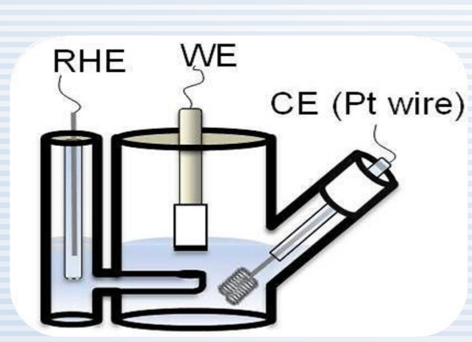
1. Pt (111);
2. Pt nanoparticles on glassy carbon.
3. Au nanoparticles on glassy carbon;
4. Au-Pt core-shell nanoparticles on glassy carbon.

Cyclic voltammograms in 0.1M H_2SO_4 solution. Scan rate: 50 mVs^{-1}.

Methods of characterization

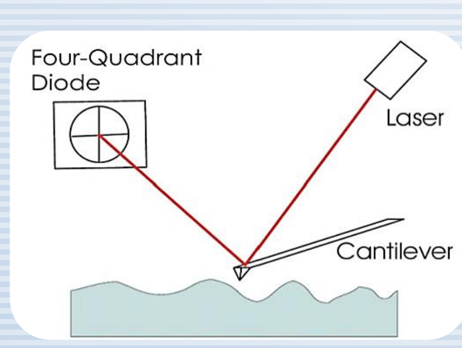
Electrochemical methods:

- cyclic voltammetry (CV), electrochemical impedance spectroscopy (EIS) and rotating disc electrode.



Microscopic techniques:

- atomic force microscopy (AFM), scanning tunneling microscopy (STM), scanning (SEM) and transmission electron microscopy (TEM).



Perspectives

1. Preparing hybrids of graphene and Pt nanoparticles or Au-Pt core shell nanoparticles.
2. Electrocatalytic testing of differently prepared materials,
3. Functional testing of 3D graphene-based catalysts in fuel cells.