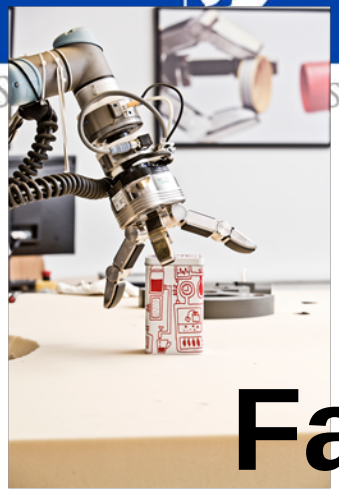
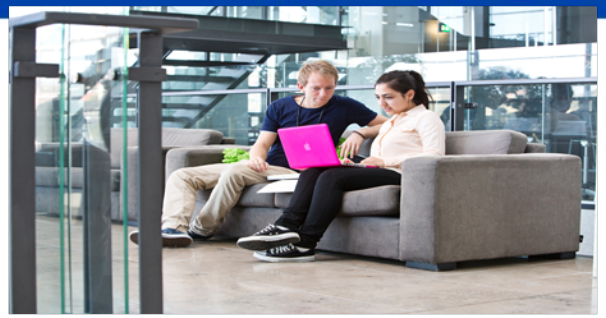
PEM fuel cell activities at KBM

Eivind M. Skou

Department of Chemical Engineering, Biotechnology and Environmental Technology

University of Southern Denmark





Faculty of Engineering at University of Southern Denmark

University of Southern Denmark

- Established 1966
- Turnover: 351 mill. EUR
- 5 faculties:
  - Engineering
  - Science
  - Health Sciences
  - Humanities
  - Business and Social Sciences
- 6 campuses
- Academic staff: 1.973
- Technical and adm. staff: 1445
- Students, total no : 26.000
- International students: 4100
- Number of programmes: 222 of which 81 is in English
- Leiden World Ranking: 192

Students per 1. Oct. 2012

From	Number	Percent
Denmark	21,930	84%
Other Nordic countries	661	2.5%
Other European countries (EU/EØS)	2,475	9.5%
Outside EU/EØS	968	4%
I alt	**26,034**	100%

Organisation

Faculty Management

Dean Per Michael Johansen
Director of Studies Henning Andersen
Head of Secretariat Søren Lind Christiansen

Department of Innovation and Technology

Nano-optics, Structural dynamics, Energy Technology, Production, Robot Mechanics, Supply Chain Management, Product Development & Innovation, Design.

Head of Department
Per Michael Johansen (ad interim)

Department of Chemical Engineering, Biotechnology and Environmental Technology

Analytical Chemistry, Spectroscopy, Natural Products Chemistry, Purification, Medicaments, Food Quality, Biogas, Biodiesel, Bacteria, Microalgae, Recombinant Proteins, Environment, Greenhouse Gases, Waste Management, Life Cycle Analysis, Advanced Materials Chemistry, Chemical Separation Techniques, Process Design.

Head of Department
Lars Porskjær Christensen

The Maersk Mc-Kinney Moller Institute

Robot and Software Technology, Biological inspired robot technology, Cognitive vision, Mathematic Modelling, Embedded Systems, Power Electronics, Robot and IT technology for industry, agriculture, healthcare and welfare.

Head of Department
Lars Dyhr

The Mads Clausen Institute (Sønderborg)

Mechatronics, Control, Power Electronics, New Energy Sources, Energy Efficiency, Modeling, Nano- Micro- og Cleanroom Technology, New light Sources, Microfluidics, User-Oriented Design, Innovation & Business.

Head of Department
Horst-Günter Rubahn

TEK THREE

Strategic focus areas – up to 2017

Strategic focus areas connecting research, education and innovation

Energy Technology	Production Technology	Welfare Technology

Multidisciplinary challenges in society, where TEK makes a difference

These areas will get extra funding through strategic projects and initiatives at the Faculty.

The new faculty

www.sdu.dk/tek

Fuel cell activities

New substrates – catalysts

- Nanocarbon tubes and fibers
- SiC
- NbC-N
- Substrate effects

Interactions at interfaces

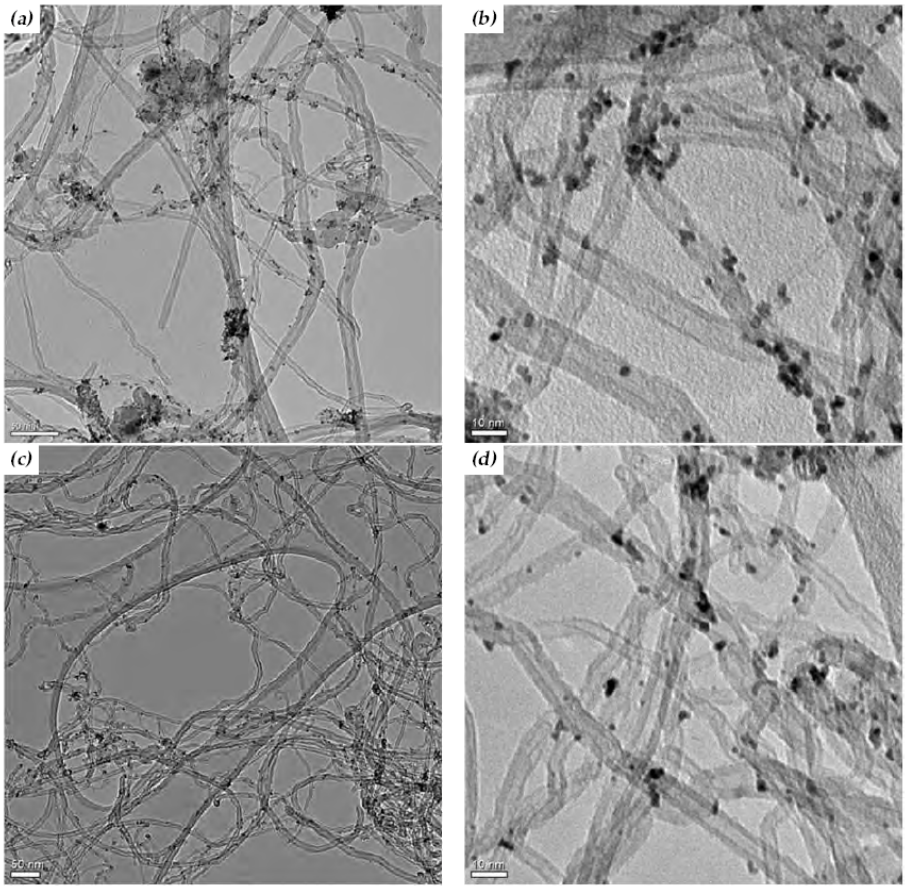
- Anion adsorption
- Ionomer adsorption

Thermal stability

- Thermogravimetry

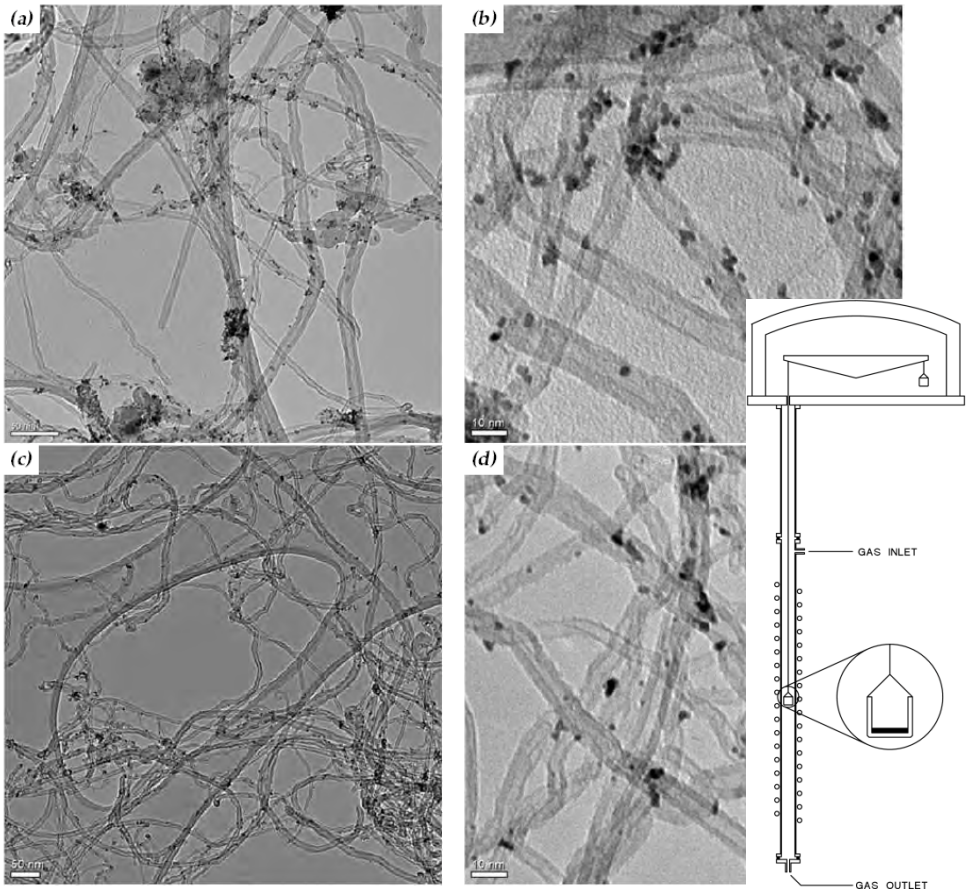
Durability

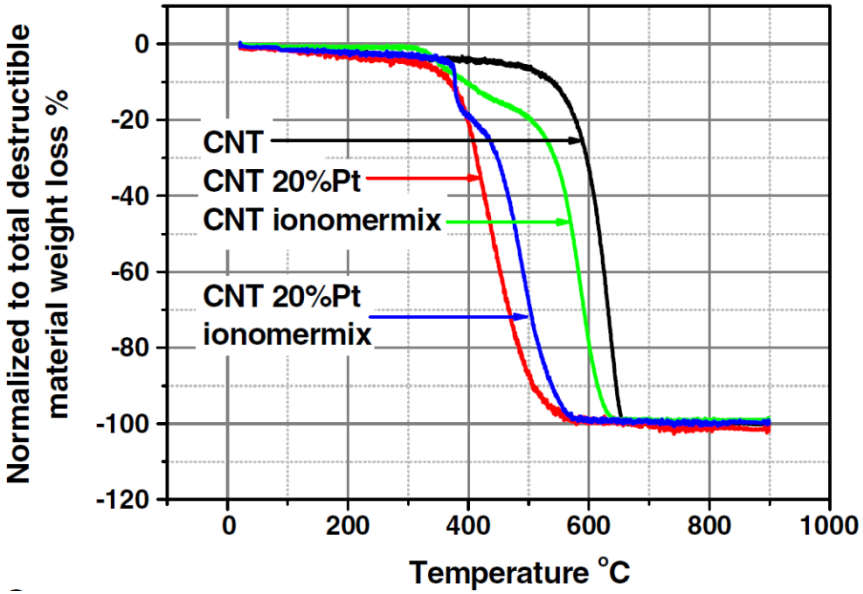
Catalyst substrates (CNF and CNT)



S.M. Andersen, M. Borghei, P. Lund. E. Yli-Rantala, A. Pasanen, E. Kauppinen, V. Ruiz, P. Kauranen and E.M. Skou: *Solid State Ionics* **231** (2013) 94

Catalyst substrates (CNF and CNT)





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Catalyst substrates (SiC)

Synthesis of SiC-nanowhiskers

The synthesis of SiC-nanowhiskers is believed to rely on a carbothermal reduction of silica which produces SiC-clusters covered in carbon which makes them hydrophobic. *

$$SiO_2(s) + C(s) \rightarrow SiO(g) + CO(g)$$

$$SiO(g) + 2C(s) \rightarrow SiC(s) + CO(g)$$

A gas-gas reaction then follows on the surface of these clusters to produce hydrophilic SiC-nanowhiskers.

$$SiO(g) + 3CO(g) \rightarrow SiC(nanowhiskers) + 2CO_2(g)$$

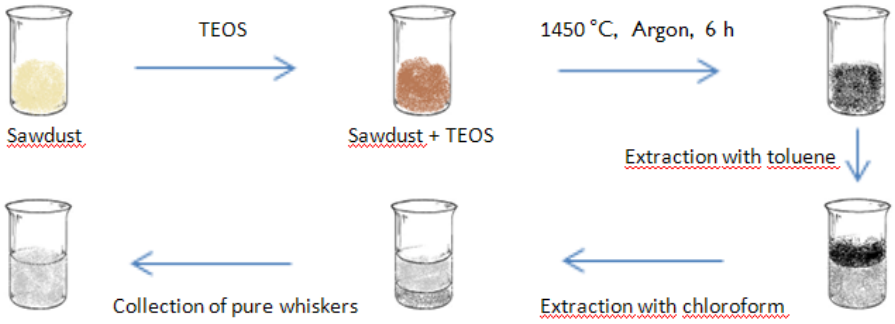
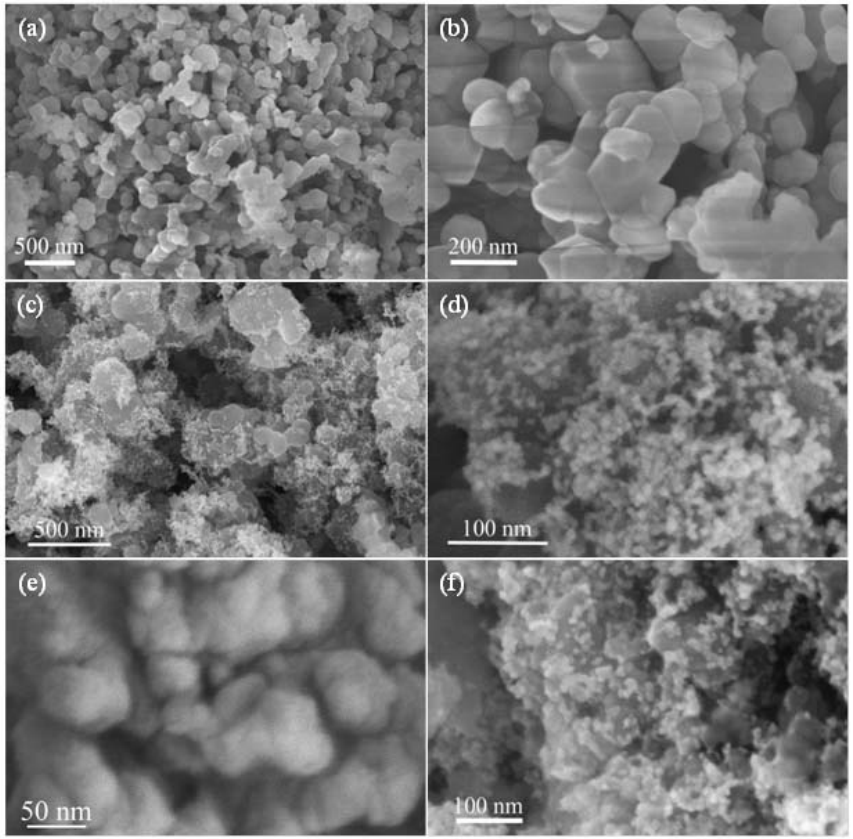
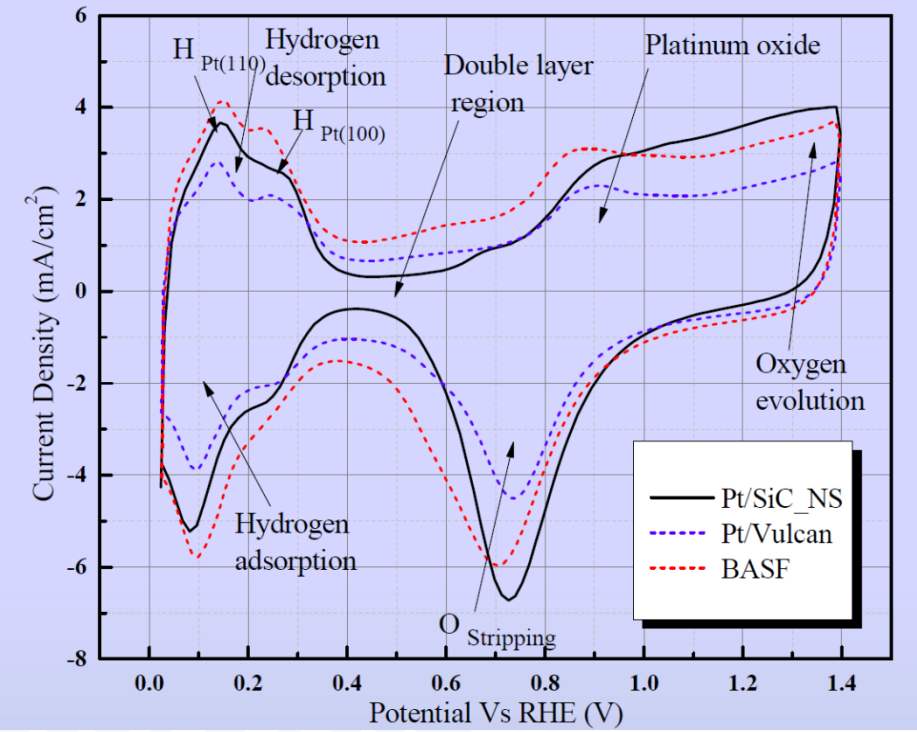


Figure 2: Diagram of synthesis and separation process.



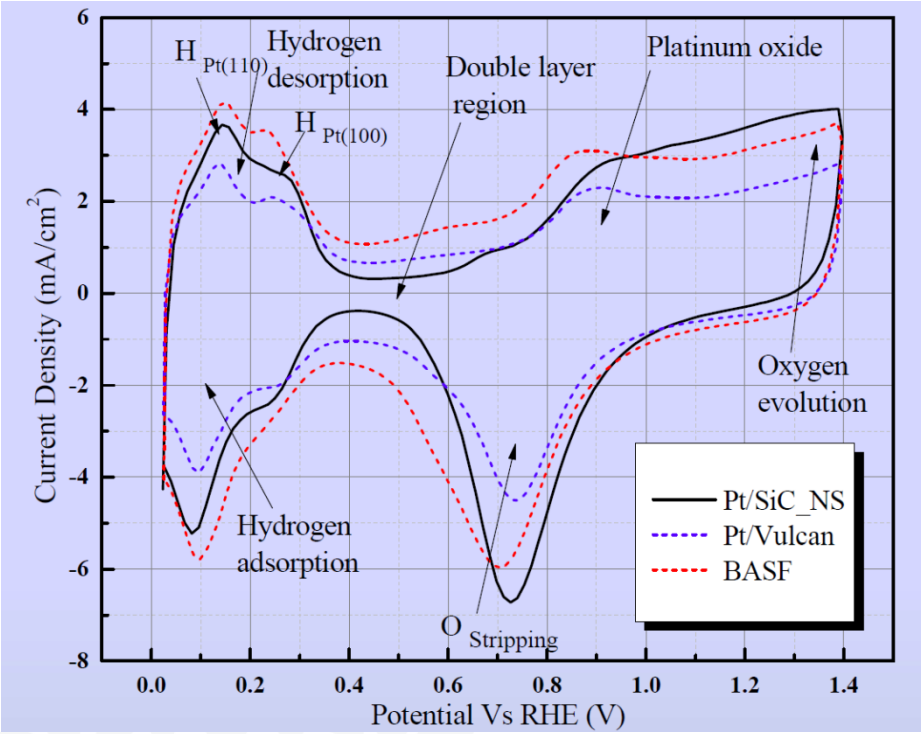
*Ref: Rajnish Dhiman, Erik Johnson, Per Morgen, *Ceramics International*, 37 (2011) 3759-3764

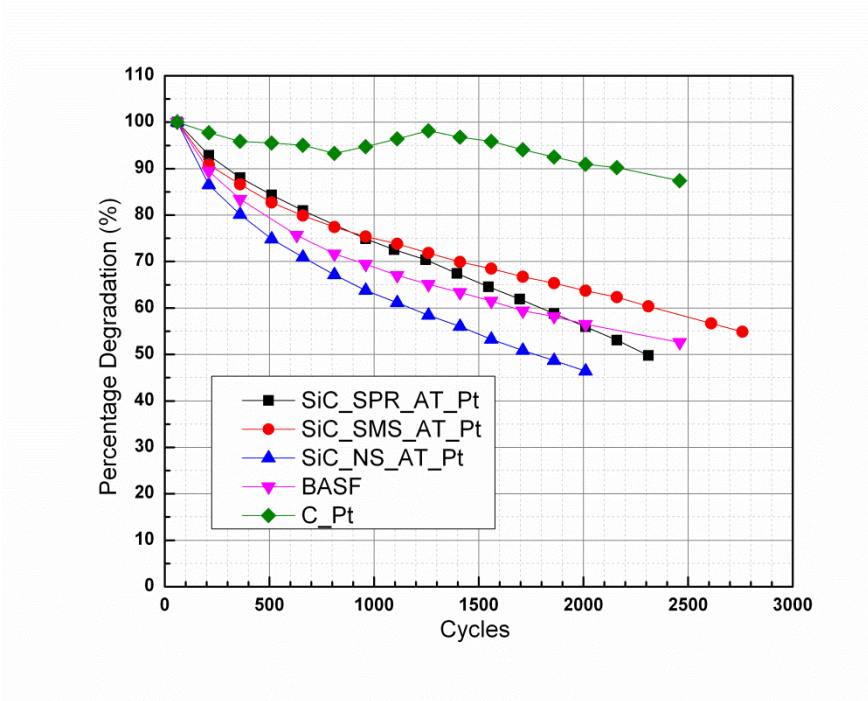
Catalyst substrates (SiC)



R. Dhiman, E. Johnson, E. M. Skou, P. Morgen, S. M. Andersen: *J. Mat. Chem. A*. **19** (2013) 6030-6036

Catalyst substrates (SiC)





R. Dhiman, E. Johnson, E. M. Skou, P. Morgen, S. M. Andersen: *J. Mat. Chem. A*. **19** (2013) 6030-6036

SiC fiber reinforcement of CsH_2PO_4

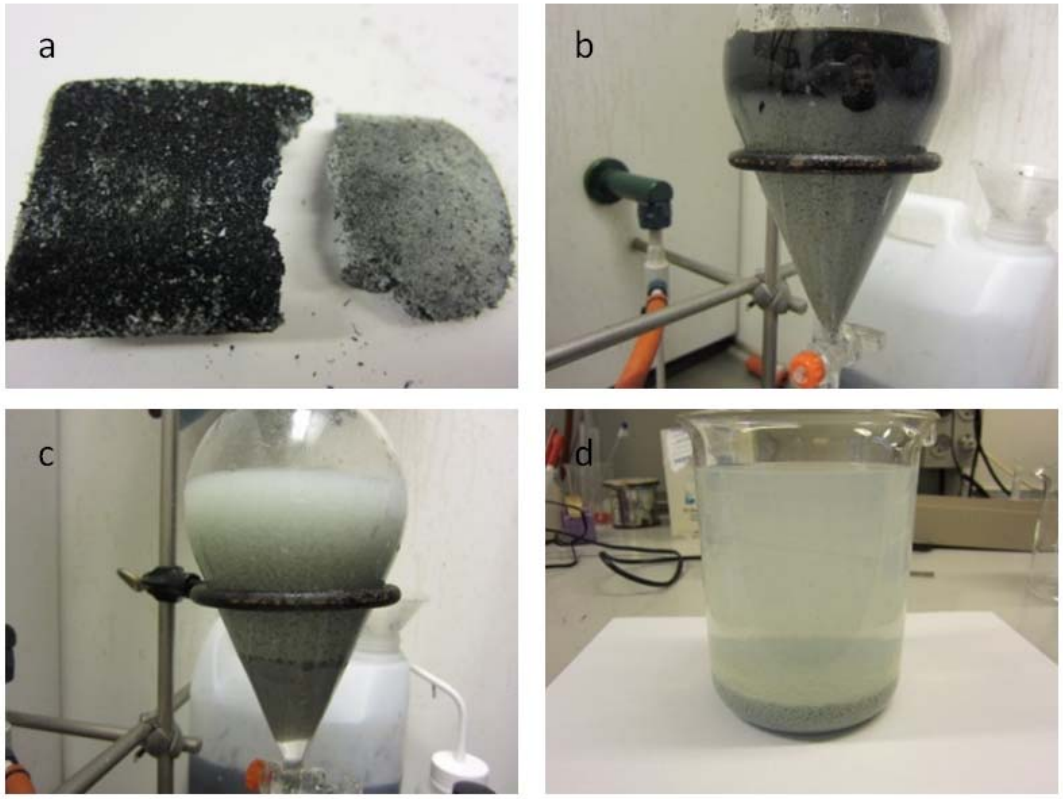


Figure 3: a) As-made mix of carbon-covered clusters and whiskers. b) Extraction with toluene. The carbonaceous phase is the top layer. c) Extraction with chloroform. The carbonaceous phase is the bottom layer. d) Final product in water after several extractions.

Catalyst substrates (NbC-N)

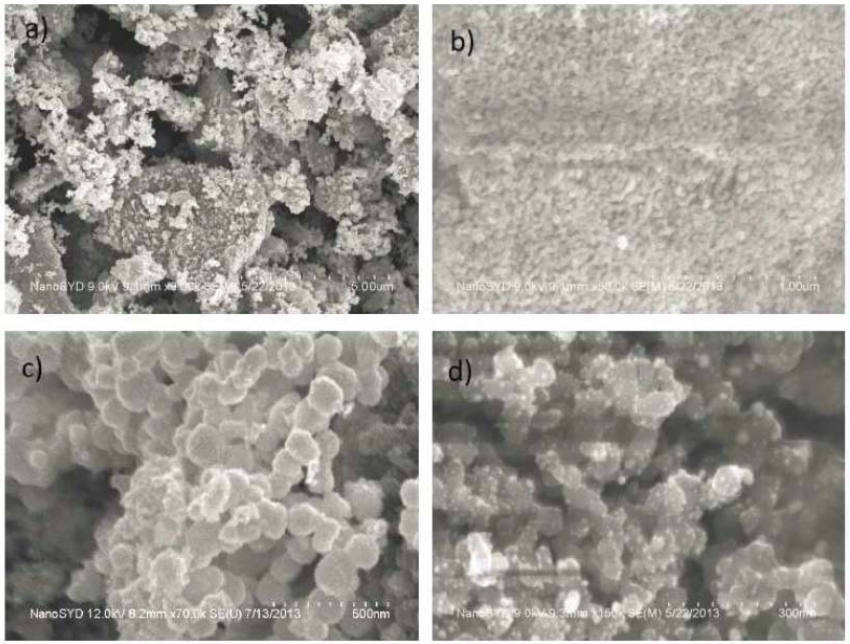
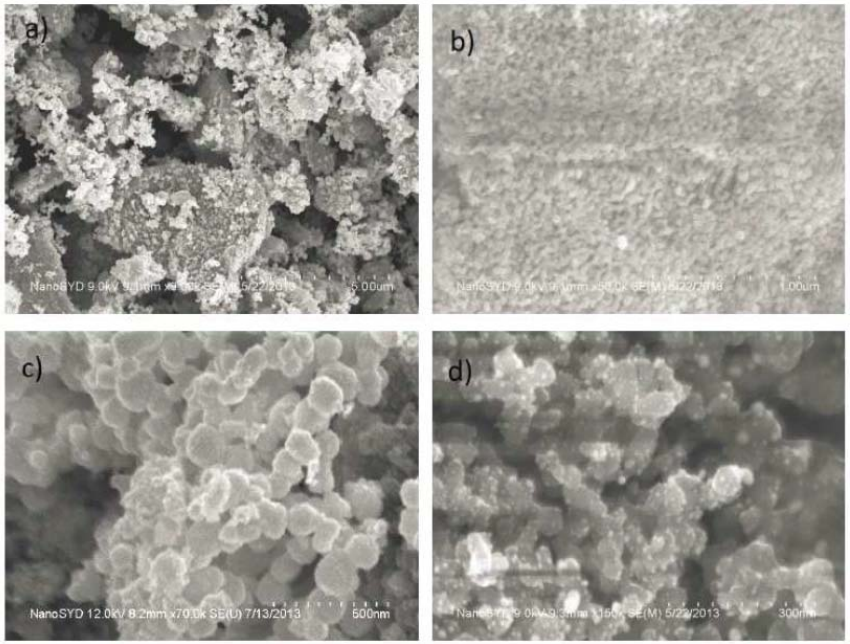


Figure 3. SEM images of Pt/NbC_xN_{1-x} at low magnifications a) and b) and high magnifications at c) and d)

S.N. Stamatin and E.M. Skou: ECS Transactions 58 (2013) 1267

Catalyst substrates (NbC-N)



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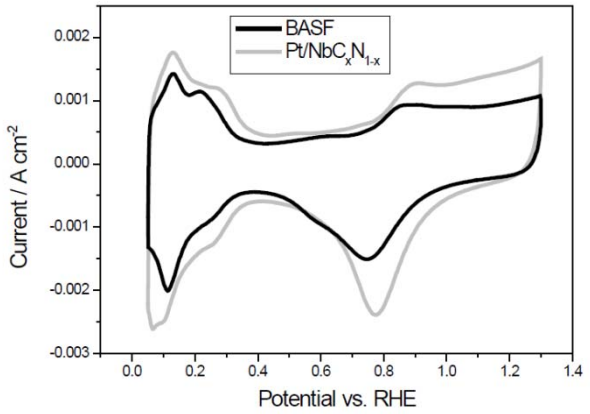

Figure 6 CV curves for Pt/NbC_xN_{1-x} (light gray) and BASF (black) in Ar saturated 0.5 M $HClO_4$ at 0.05 V s^{-1}

S.N. Stamatin and E.M. Skou: ECS Transactions 58 (2013) 1267

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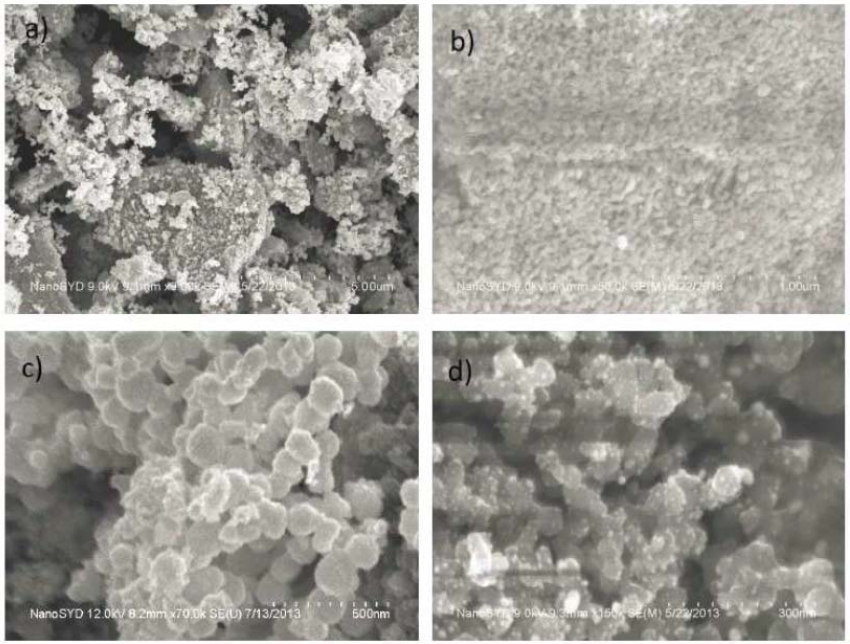

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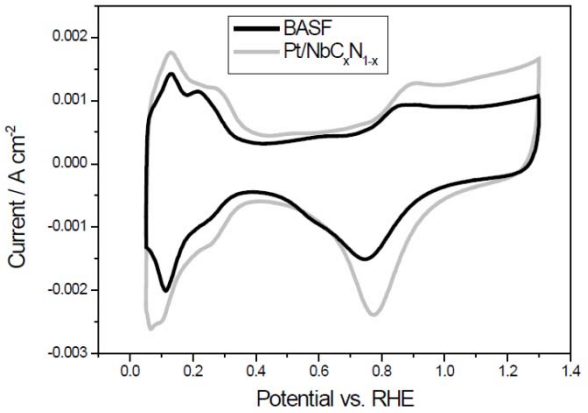

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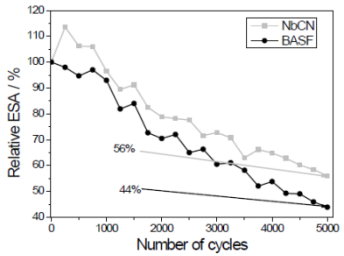


Figure 9 Relative ESA vs. number of potential cycle for BASF (black) and NbC_xN_{1-x} (light gray)

S.N. Stamatin and E.M. Skou: ECS Transactions 58 (2013) 1267

Substrate effects

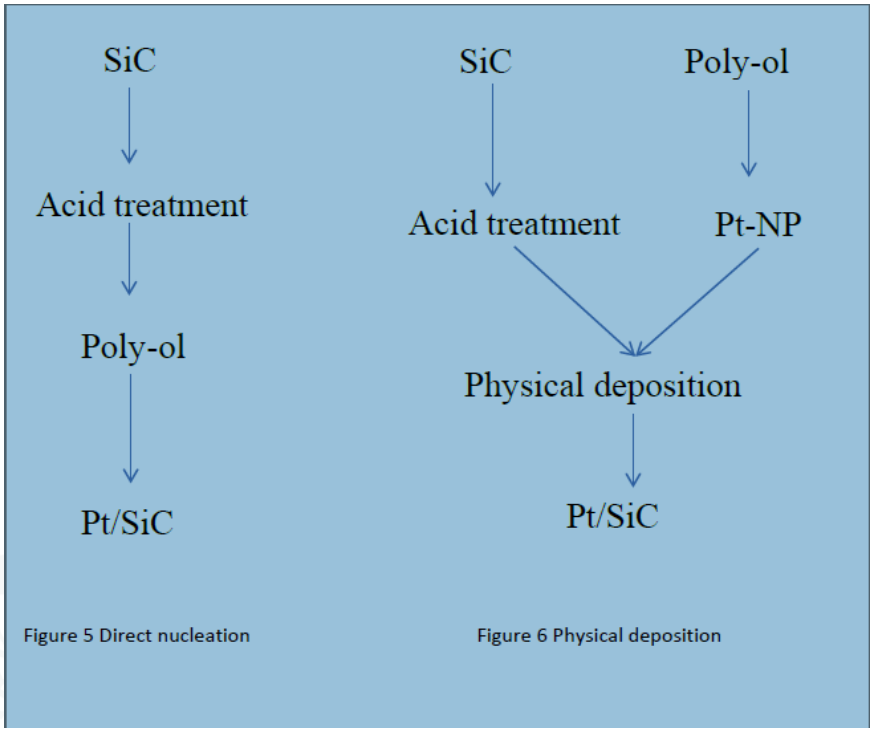


Figure 5 Direct nucleation

Figure 6 Physical deposition

Substrate effects

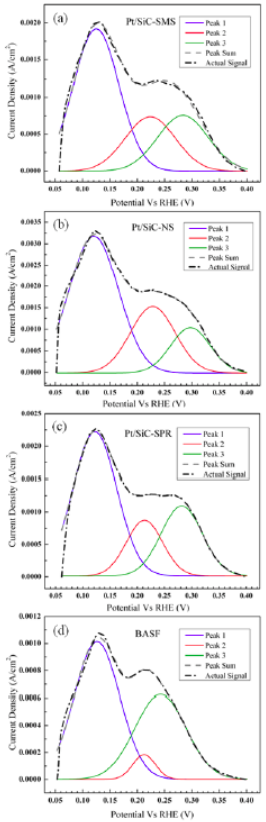
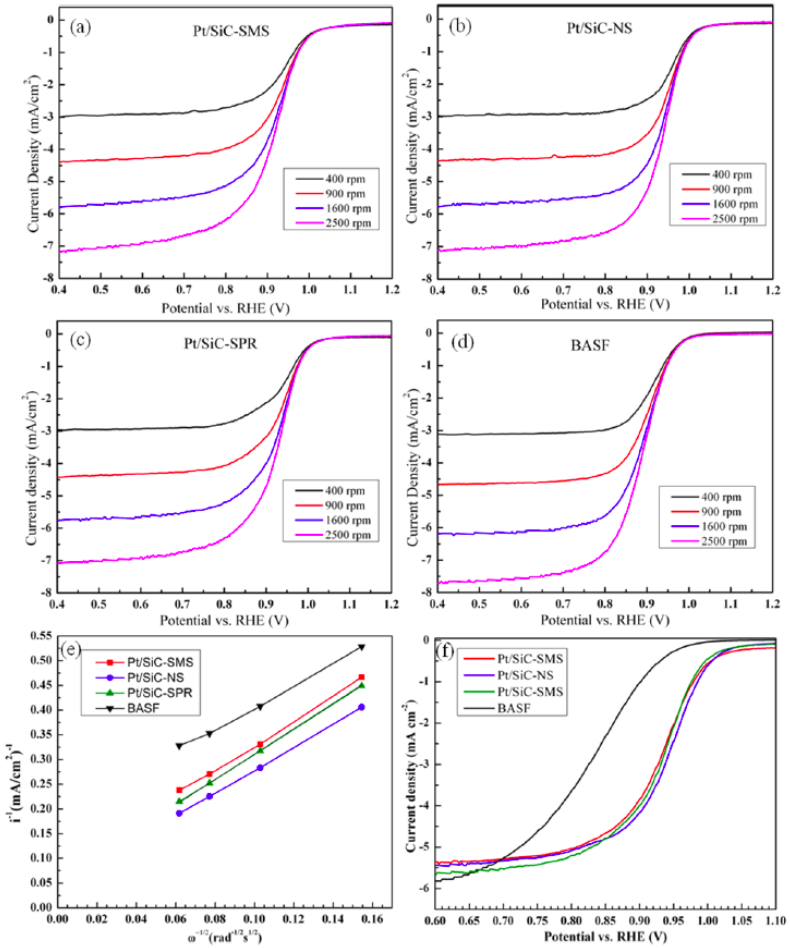
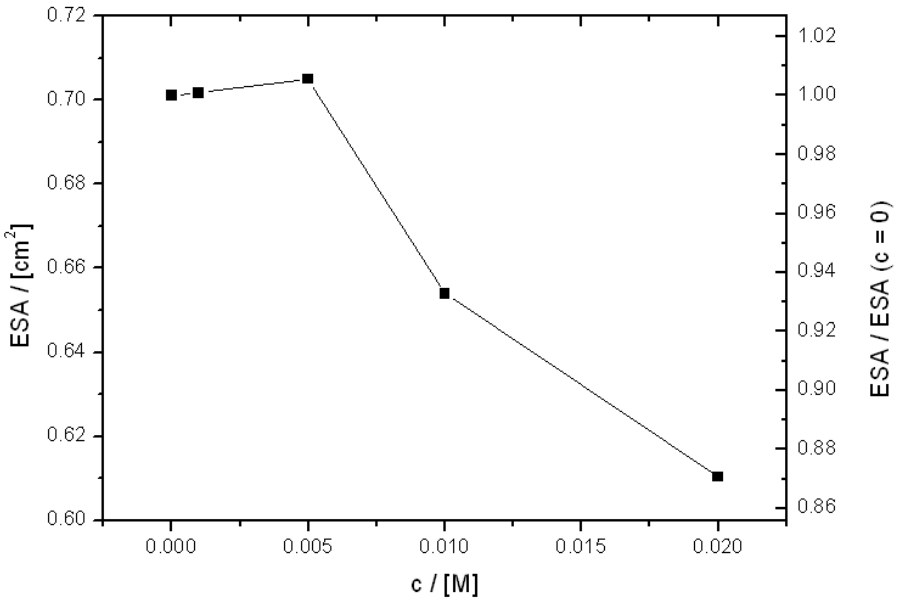


Fig. 4 Peak deconvolution of the cyclic voltammograms of different samples in the H desorption region. Pt loading on electrodes is 30 μg/cm² for BASF and 120 μg/cm² for SiC based catalyst samples.



Rajnish Dhiman, Serban N. Stamatin, Shuang M. Andersen, Per Morgen and Eivind M. Skou: *J. Mat. Chem.* , submitted

Interactions – anion adsorption

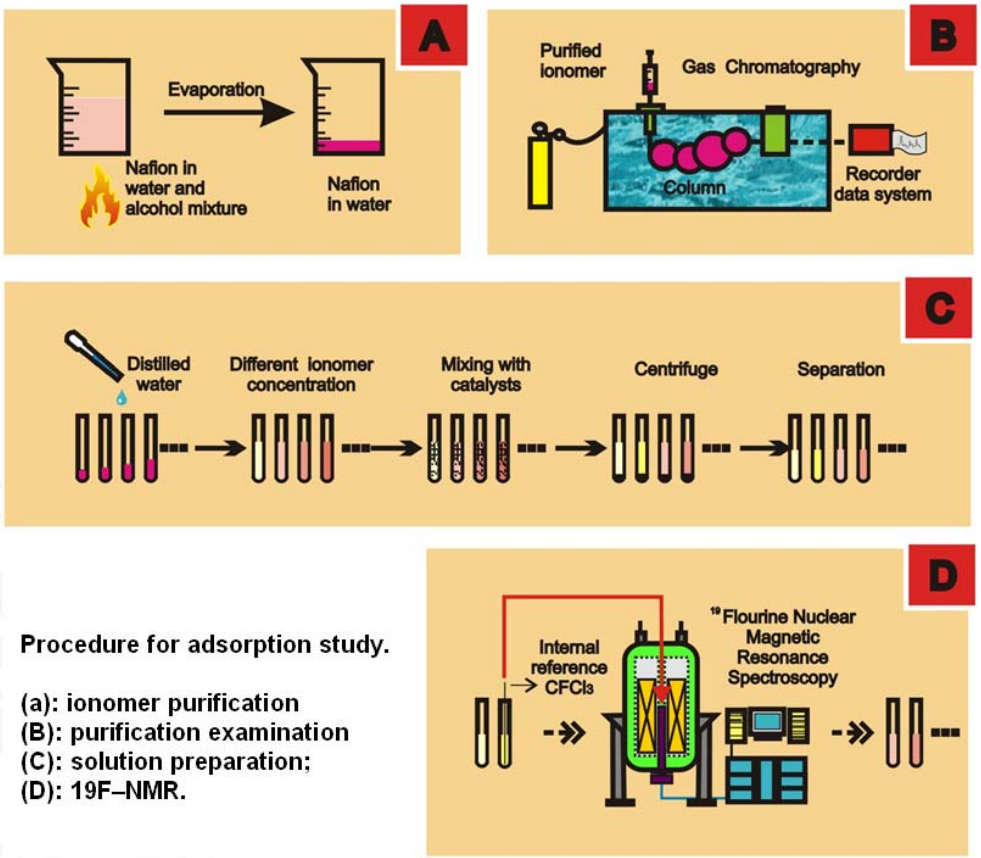


¶

ESA·of·platinum·as·a·function·of·phosphoric·acid·concentration.·The·fraction·of·free·platinum·surface·is·shown·on·the·second·Y-axis.¶

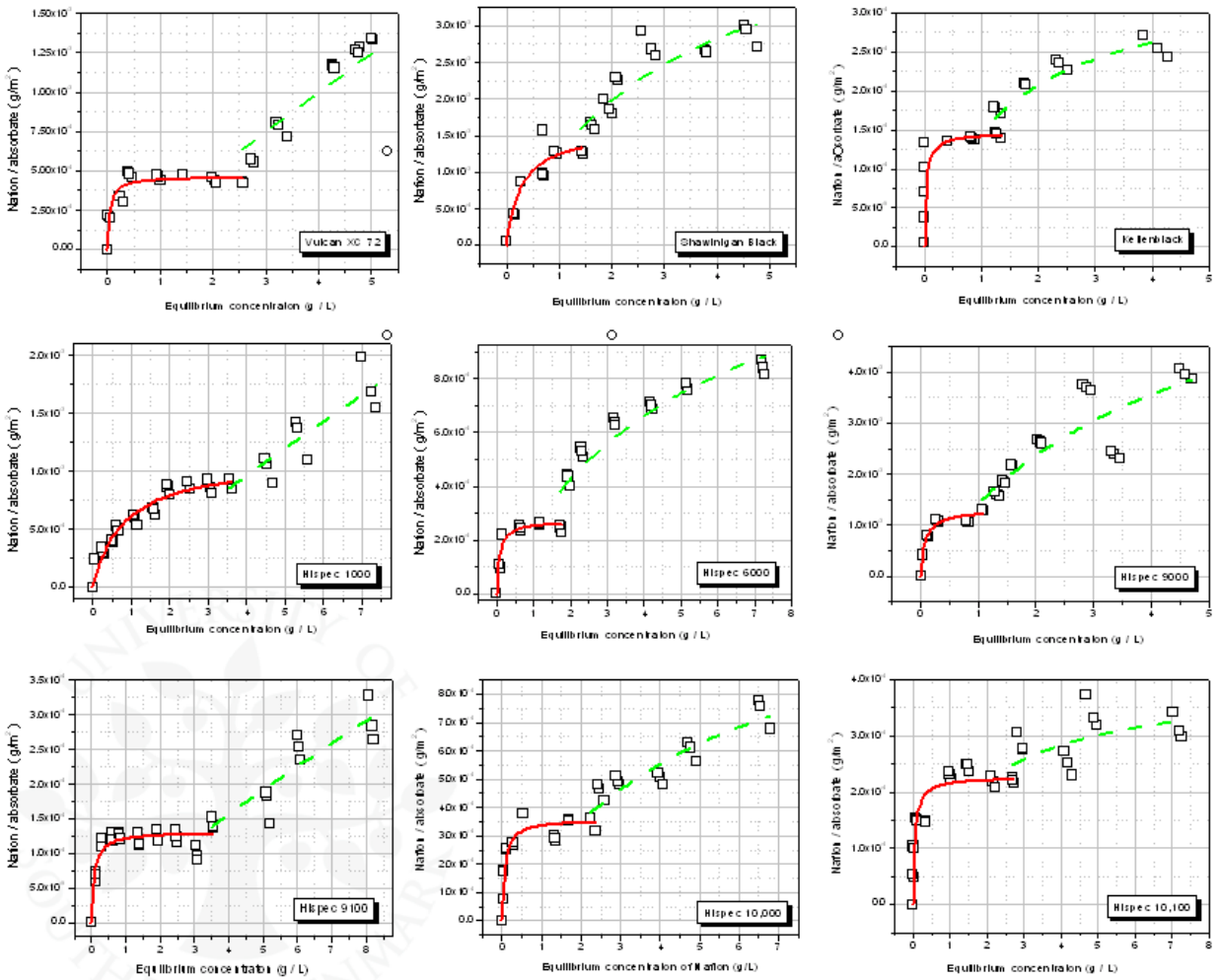
Daniel Risskov Sørensen: Internal report

Interactions – ionomer adsorption



Procedure for adsorption study.

(a): ionomer purification
(B): purification examination
(C): solution preparation;
(D): 19F–NMR.

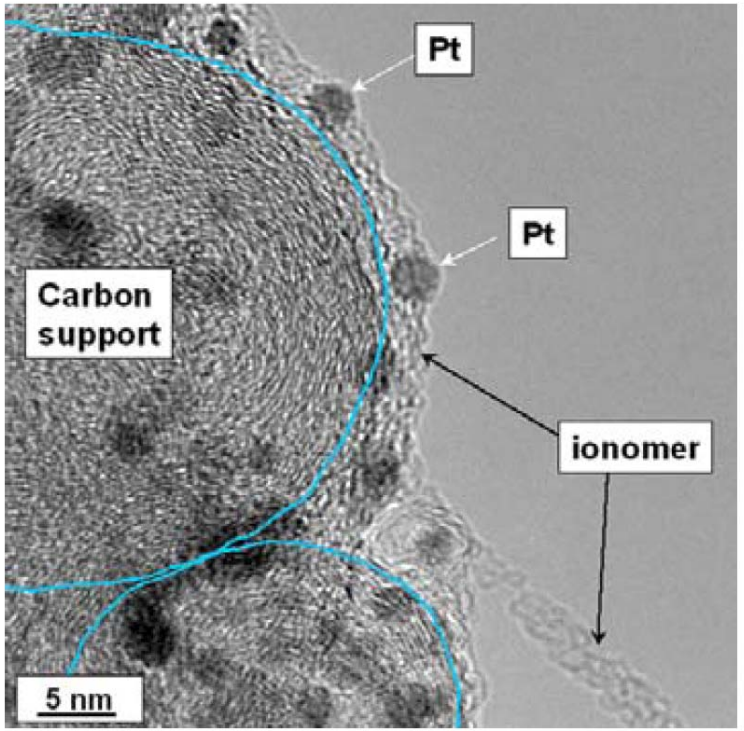


Adsorption isotherms on carbon or catalyst.

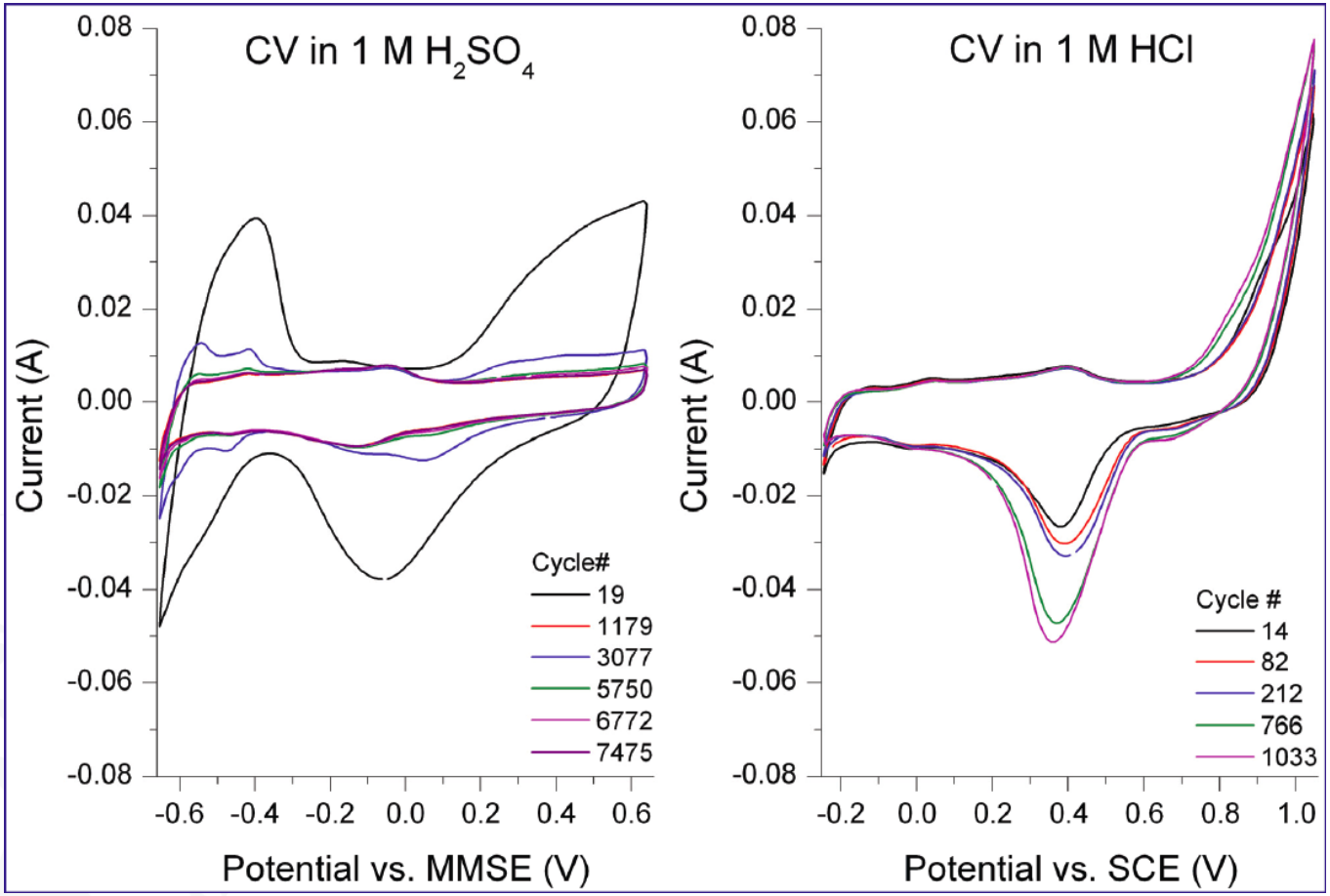
Shuang Ma, Qian Chen, Flemming H. Jørgensen, Paul C. Stein and Eivind M. Skou: *Solid State Ionics* **178** (2007) 1568

Ionomer adsorption

There is a strong interaction between the membrane binder in the electrode and the catalyst



Durability



Casper Frydendahl: Internal report

Group members

Eivind Skou, professor

Terence Warner, ass. professor

Shuang Ma Andersen, ass. professor

Ulla Gro Nielsen ass. professor FKF

Per Morgen, ass. professor emer. FKF

Casper Nørgaard, post. doc.

Rajnish Dhiman, post. doc.

Daniel Risskov Sørensen. ph.d. student

Serban Stamatin, ph.d. student

Steffen Thrane Vindt, ph.d. student

Thank You