Dr. Marwan Chemie
Forschung & Entwicklung

Understanding the Palladium Hydrogen (Deuterium) Electrochemistry as Crucial Step to Approach Low Energy Nuclear Reactions

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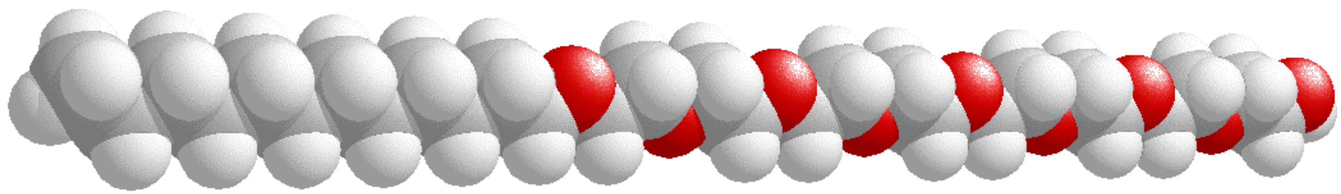
Properties of Nanostructures

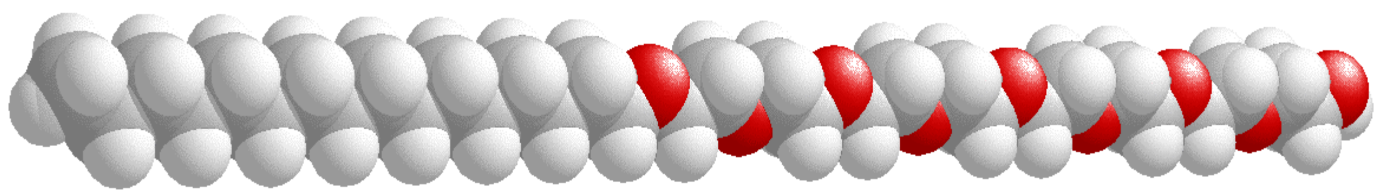
- Rapid insertion reactions (fast insertion and removal of H into and from bulk - Pd)

- adsorption- and absorption process distinguishable in the voltammetry

Surfactants:

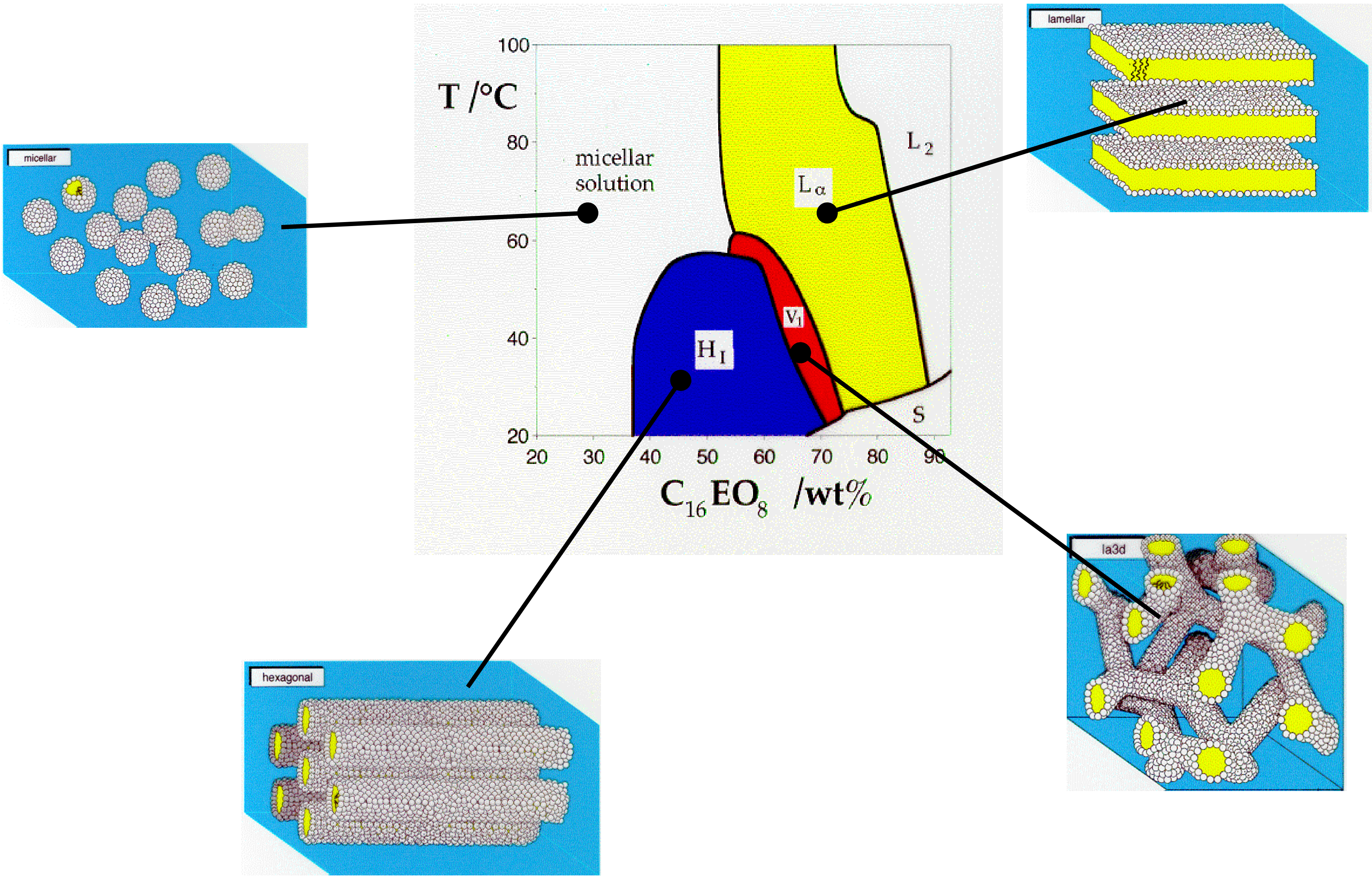


Octaethylene glycol monododecyl ether ($C_{12}EO_8$)

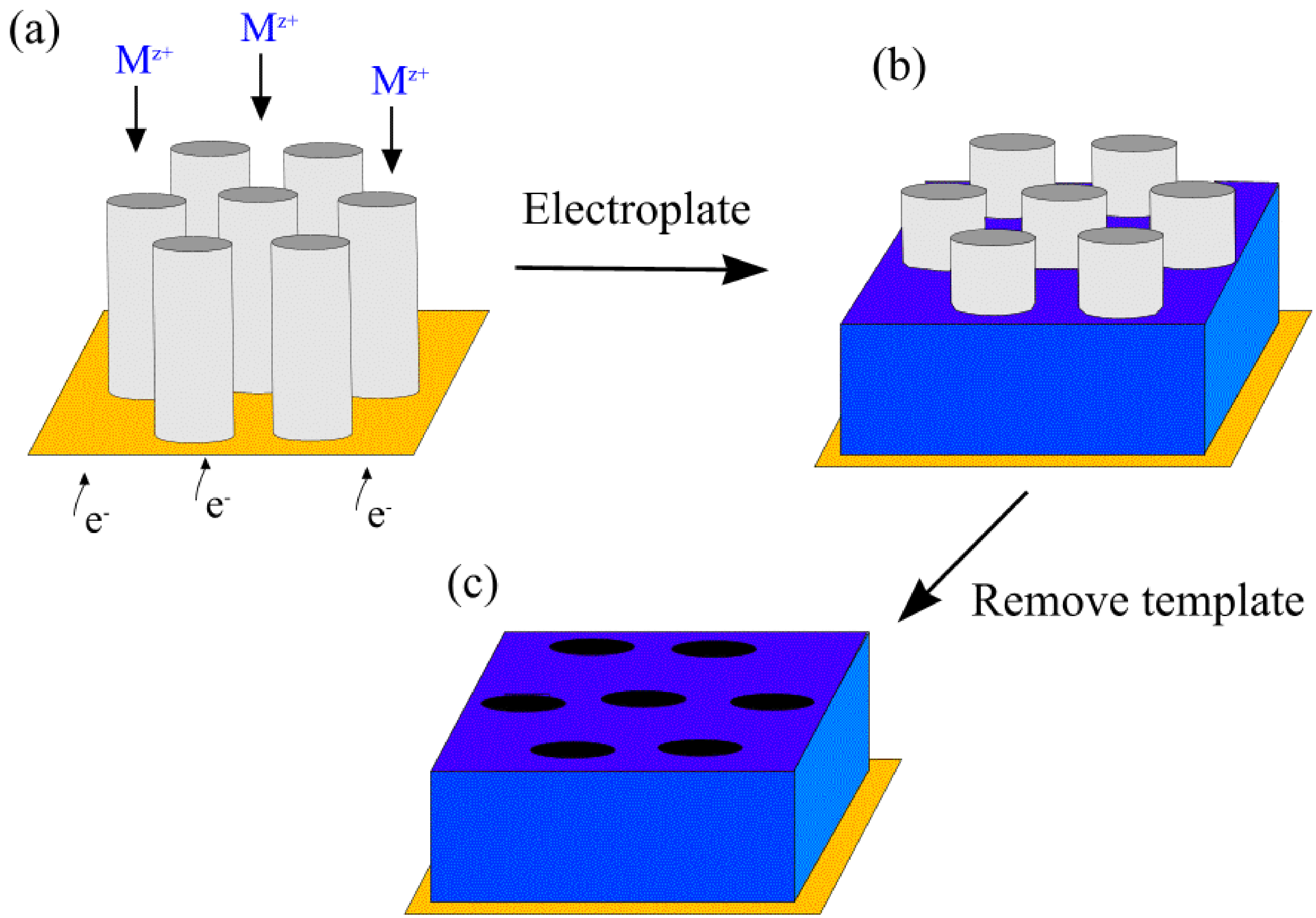


Octaethylene glycol monohexadecyl ether ($C_{16}EO_8$)

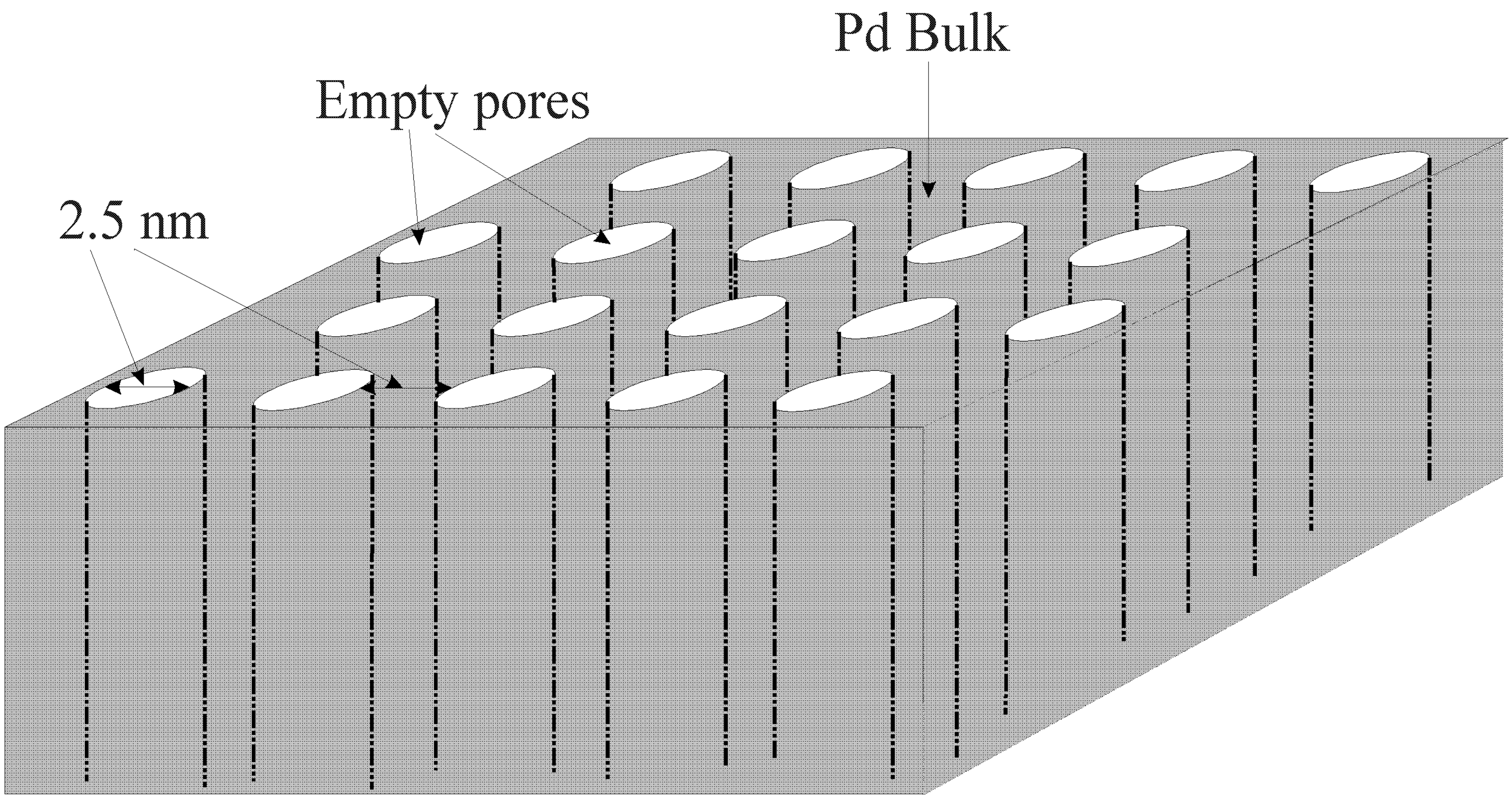
Phase diagram



Templated Electrodeposition:



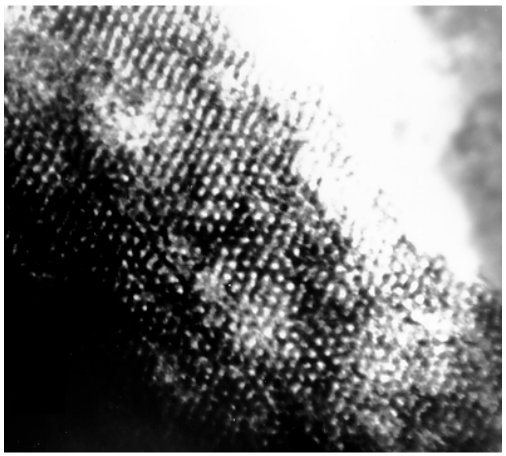
The porous structure of the metal film



Nanostructured platinum films:

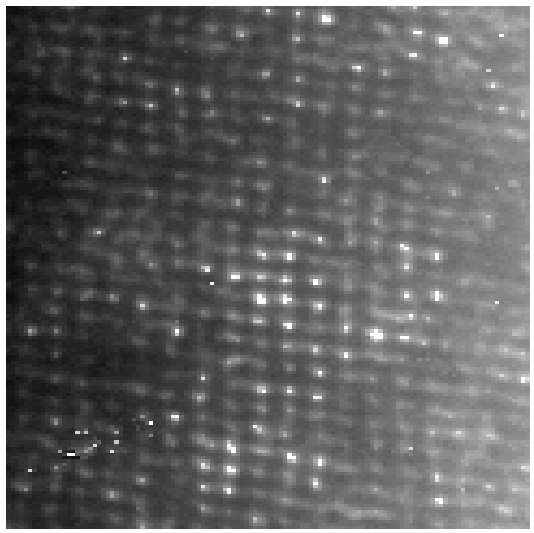
formed by electrochemical deposition from lyotropic phases

Hexagonal H_I



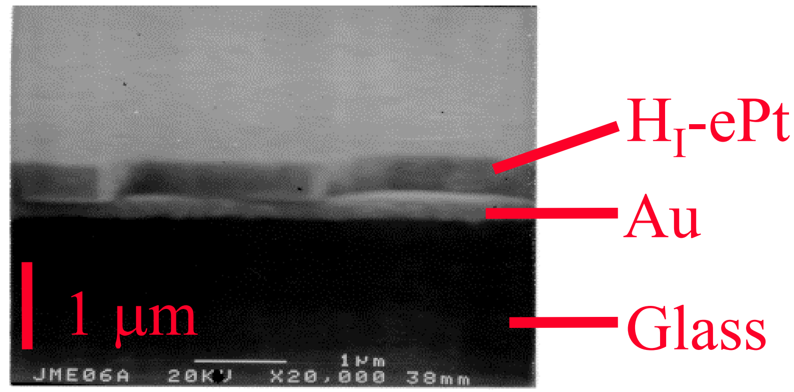
— 50 nm

Cubic V_I



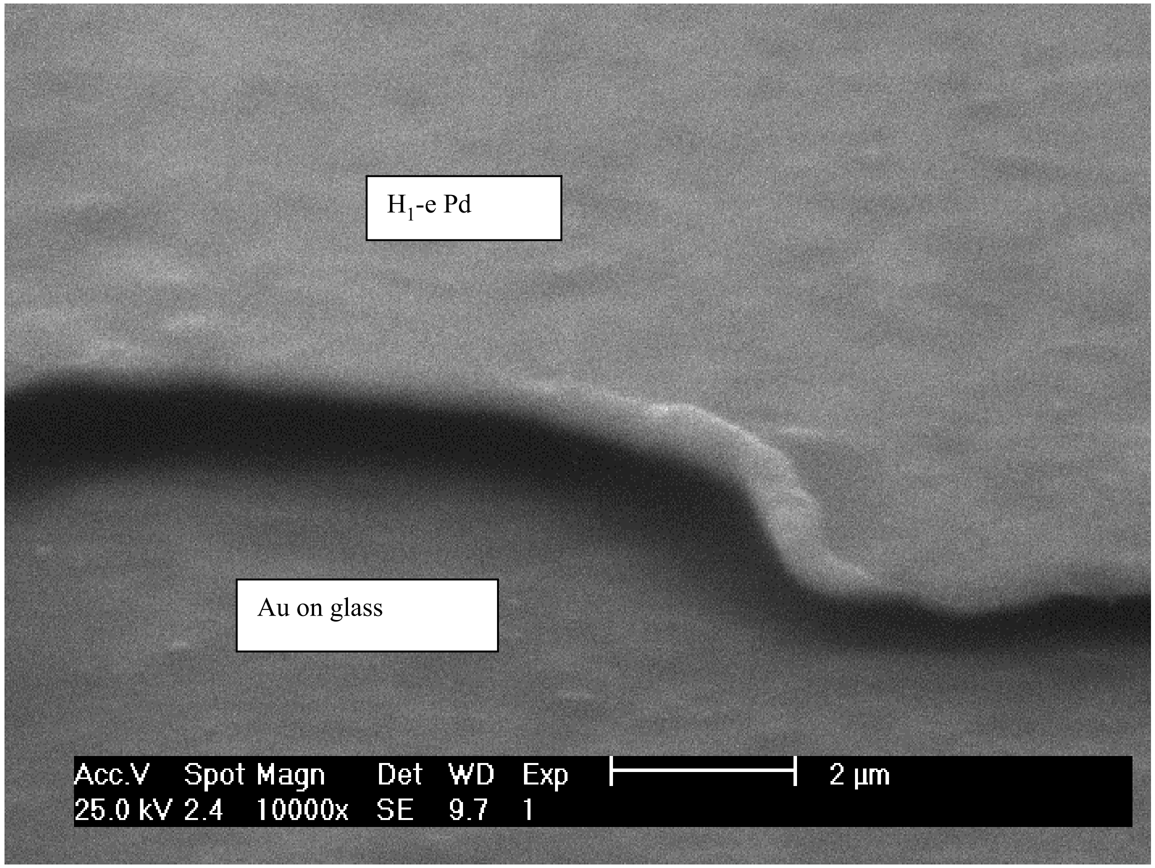
50 nm

SEM Image



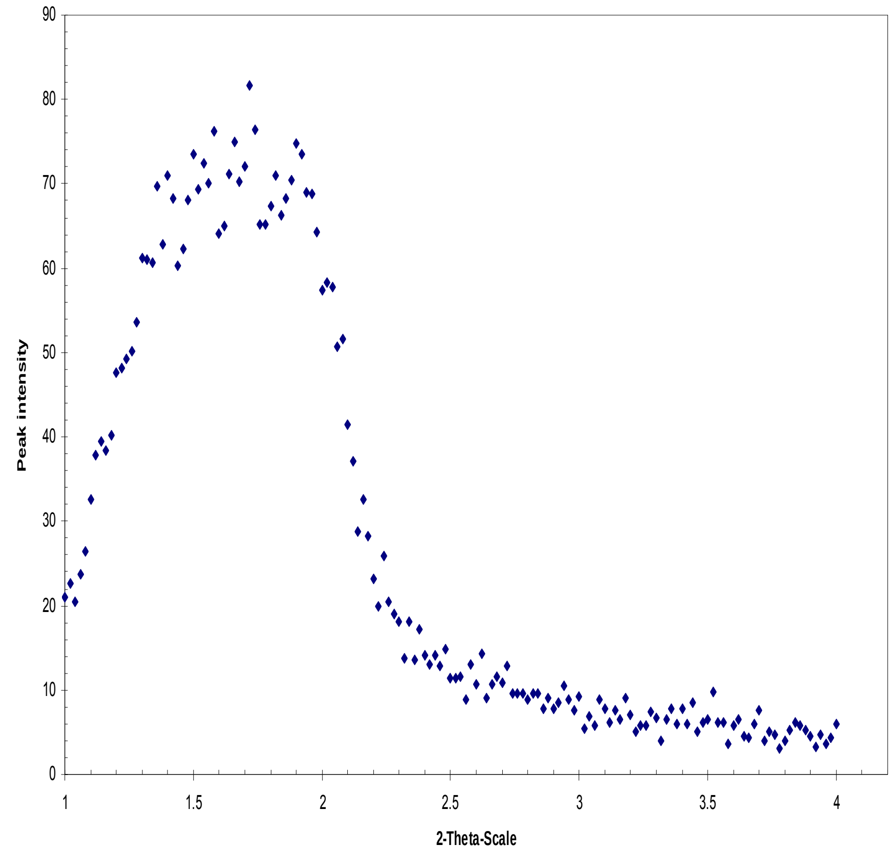
Science, ***278***, 838 (1997).

SEM of nanostructured Pd



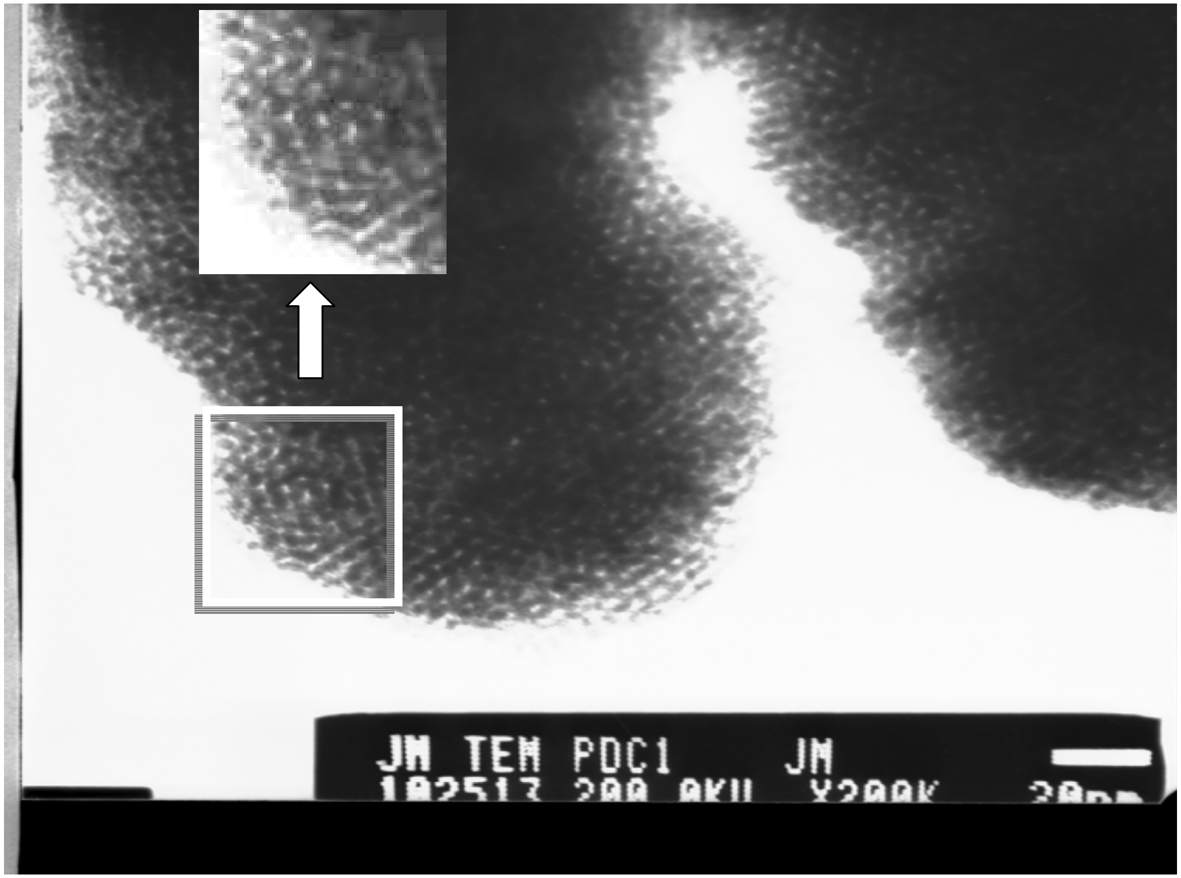
Deposited from H_1 lyotropic liquid crystalline phase (12% $(NH_4)_2PdCl_4$, 47% $C_{16}EO_8$, 39% water, 2% heptane by weight) at 0.1 V vs SCE.

TEM and XRD of nanostructured palladium



Deposited from H_1 lyotropic liquid crystalline phase (12% $(NH_4)_2PdCl_4$, 47% $C_{16}EO_8$, 39% water, 2% heptane by weight) at 0.1 V vs SCE.

TEM of nanostructured palladium

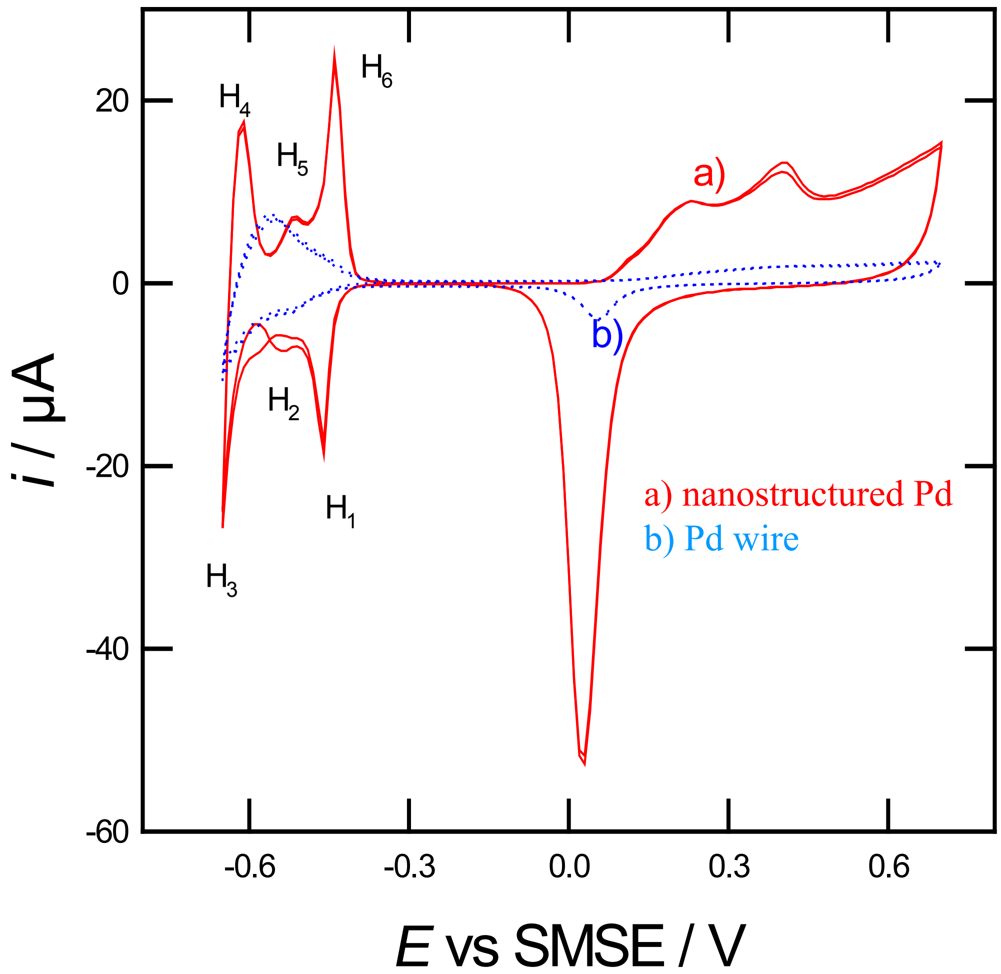


Deposited from H_1 lyotropic liquid crystalline phase (12% $(NH_4)_2PdCl_4$, 47% $C_{16}EO_8$, 39% water, 2% heptane by weight) at 0.1 V vs SCE.

TEM of nanostructured rhodium

Deposited from H_1 lyotropic liquid crystalline phase (12 wt% $RhCl_3$, 47 wt% $C_{16}EO_8$, 39 wt% water, 2 wt% heptane) at -0.2 V vs SCE

Electrochemical properties of nanostructured palladium



20 mV/s
1M H_2SO_4

a) 0.002 cm^2 electrode area

b) 0.54 cm^2 surface area, corresponds to 27.6 m^2/g and 10^7 cm^2/cm^3

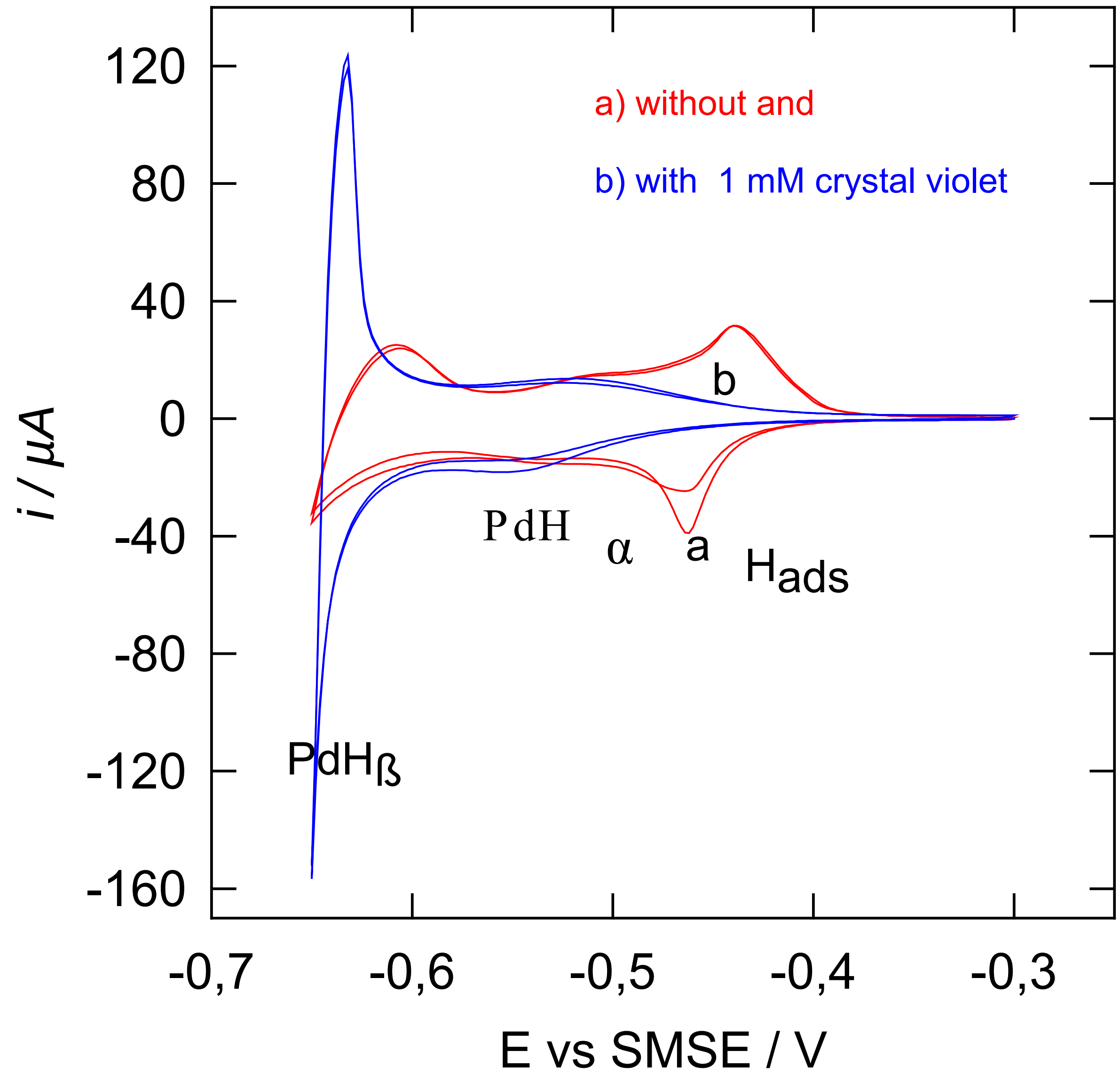
Hydrogen electrode reaction

$H_3O^+ + e^- \rightarrow H_{ads} + H_2O$ Volmer

$H_{ads} + H_3O^+ + e^- \rightarrow H_2 + H_2O$ Heyrovsky

$H_{ads} + H_{ads} \rightarrow H_2$ Tafel

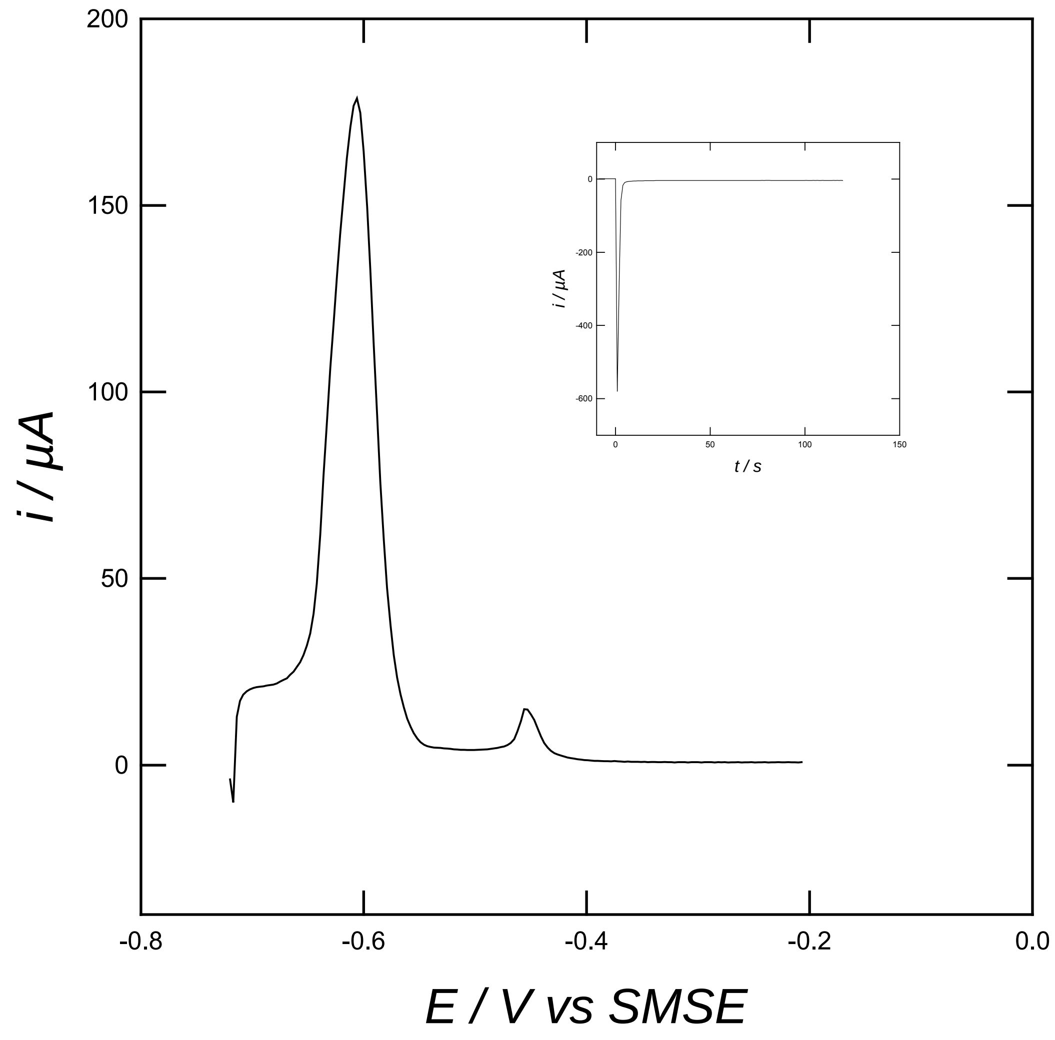
Additives affecting the H - adsorption



20mV/s

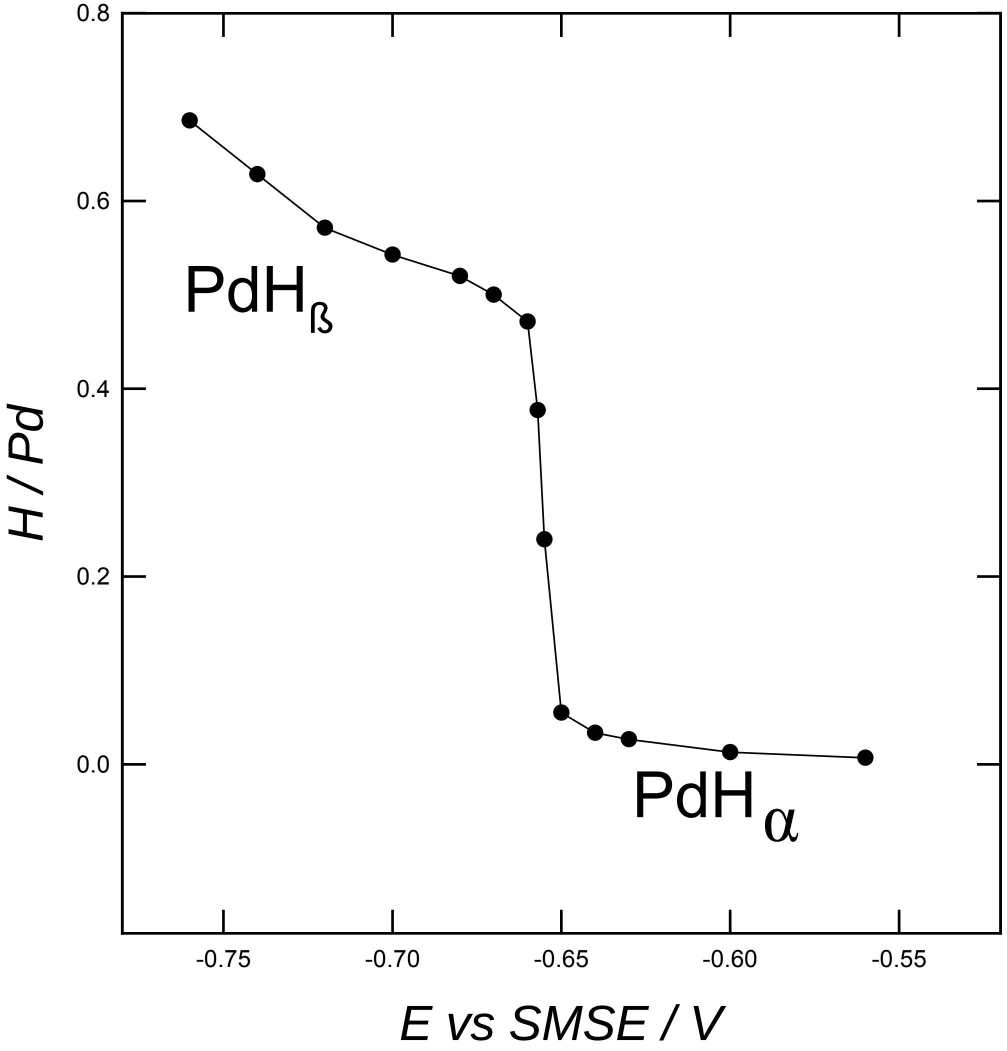
1 M H_2SO_4

H - insertion into Pd



Potential was stepped to -0.72 V.
After holding the electrode for 120 s it was swept back to -0.2 V at 10 mV/s.

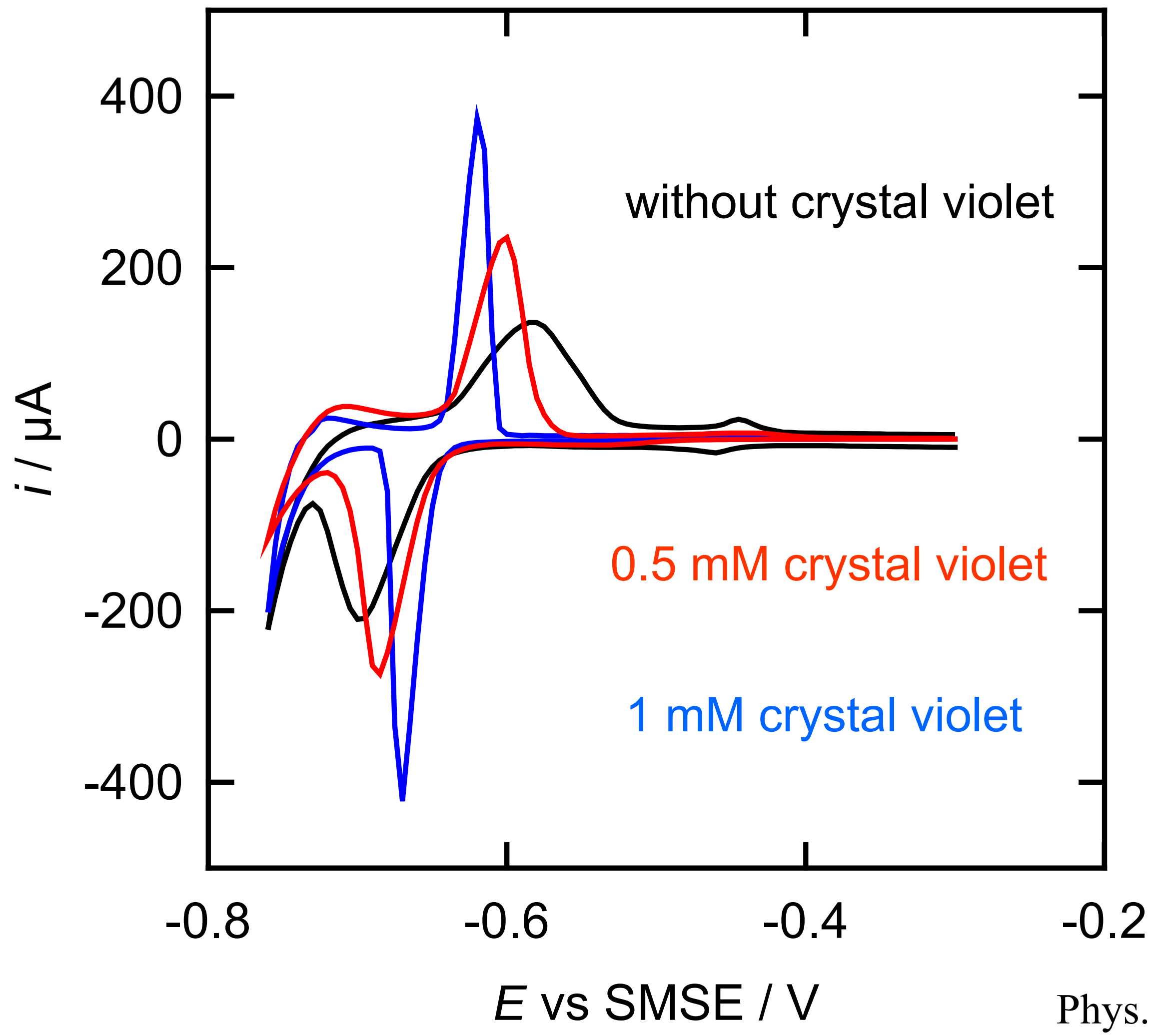
Pd - Hydride phases



H was loaded into bulk-Pd at different potentials.
The electrode was held at each potential for 120s and swept back to -0.2V.

Phys. Chem. Chem. Phys., 2002, **4**, 3835

Increasing crystal violet coverage on Pd surface



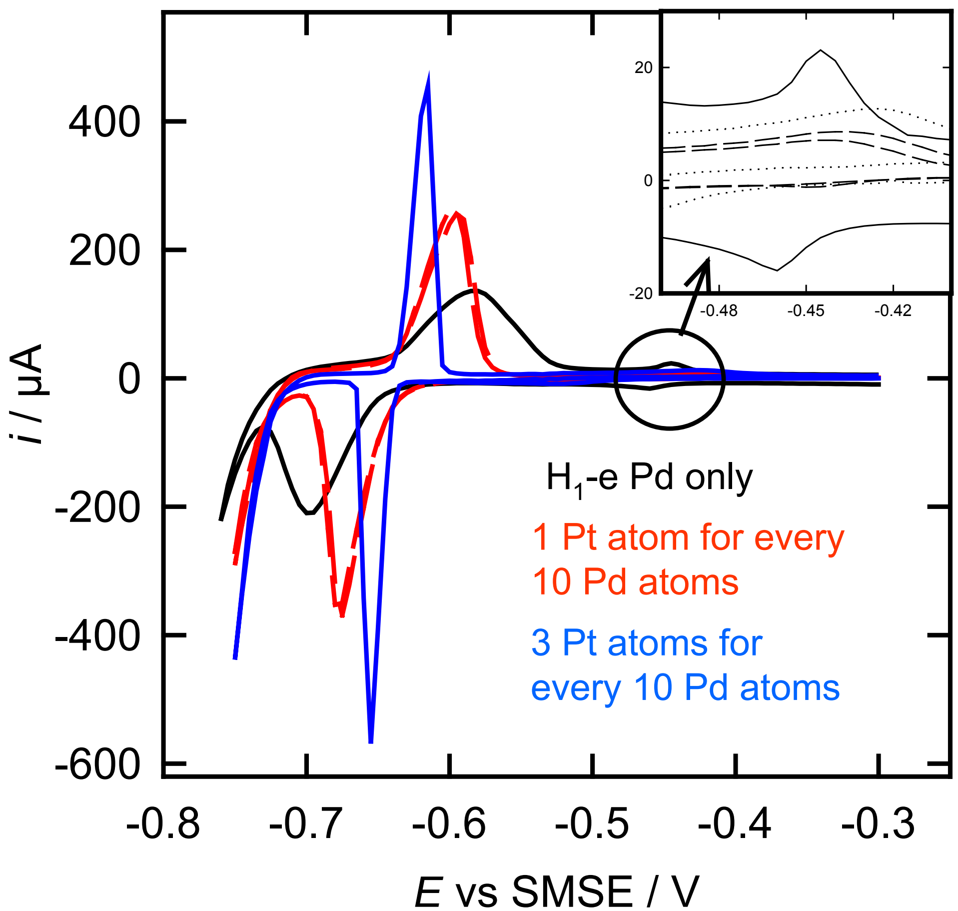
10 mV/s
1 M H_2SO_4

3.5 mC deposition charge

Phys. Chem. Chem. Phys. 2004, **6**, 2895

H_1-e Pd initially deposited on gold (0.0079 cm^2)

Increasing Pt coverage on Pd surface

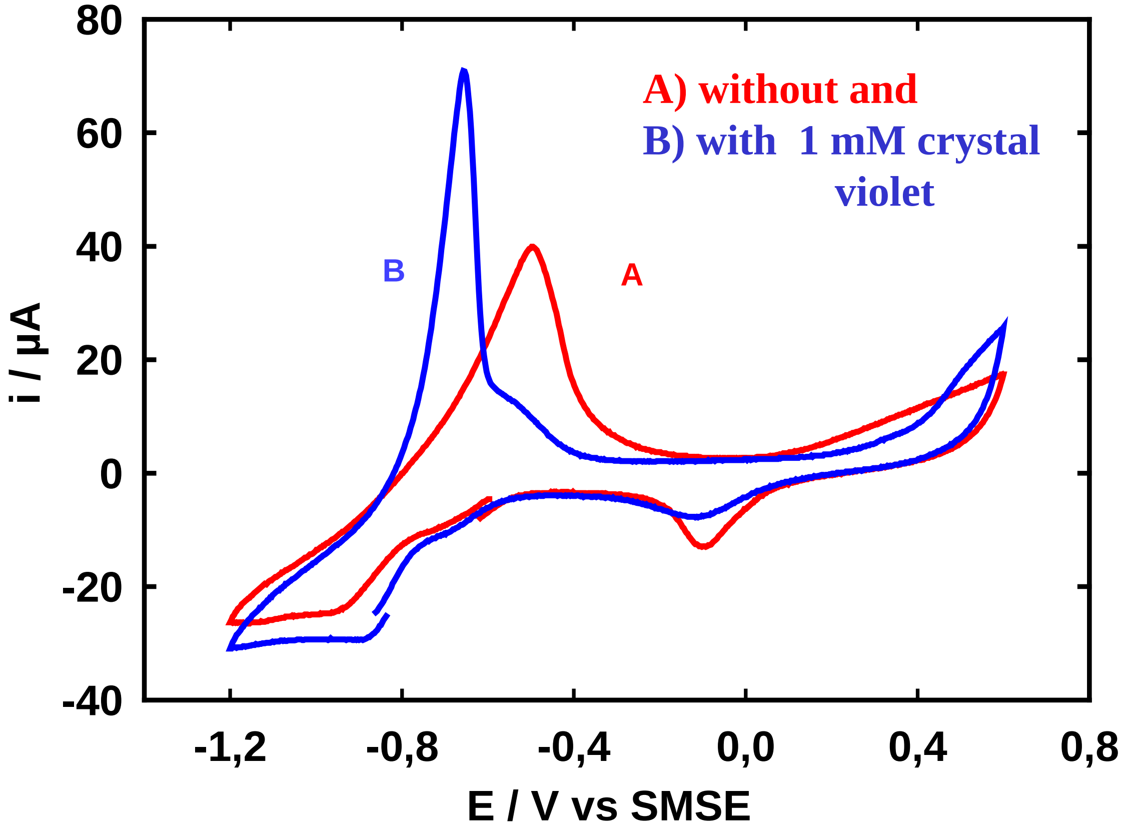


10 mV/s
1 M H_2SO_4

3.5 mC deposition charge

H_1-e Pd initially deposited on gold (0.0079 cm^2)

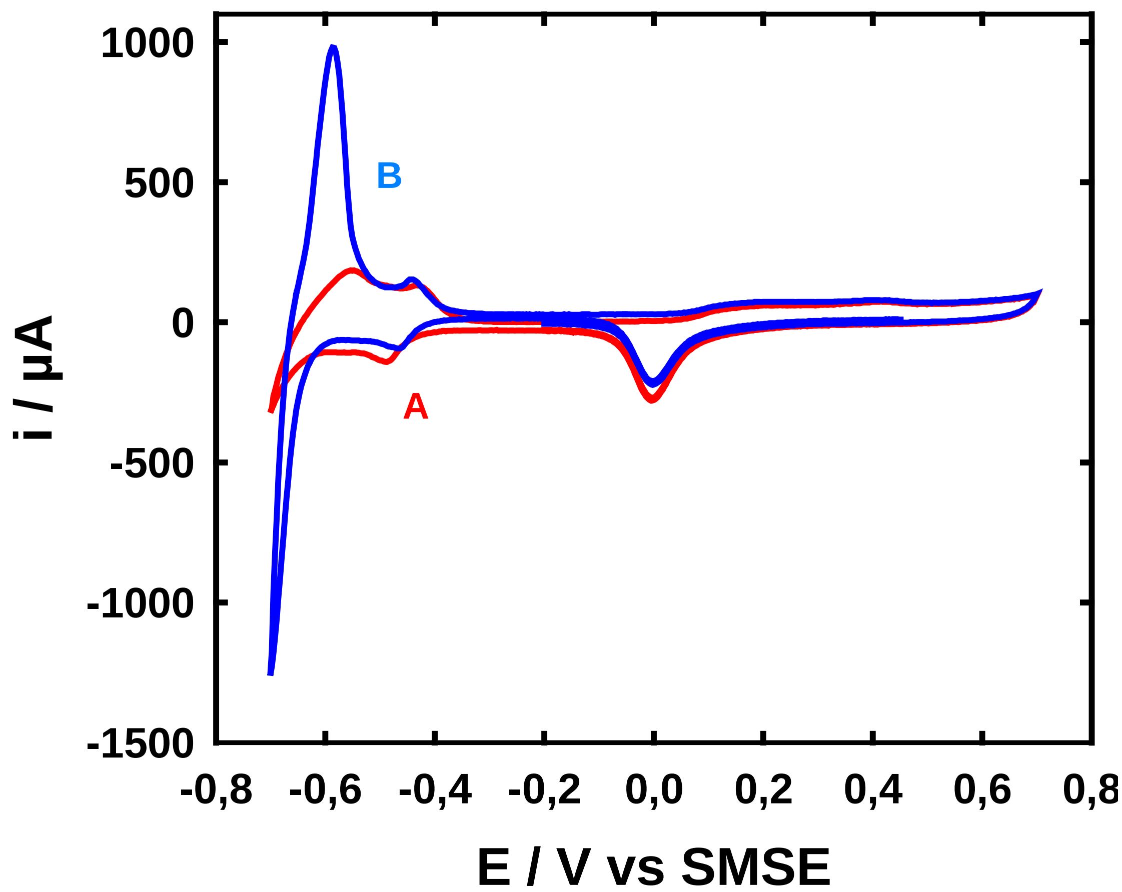
Additives affecting the D - adsorption



20 mV/s

D_2O + 0.1 M Li_2SO_4

Electrolysis



100 mV/s

1 M H_2SO_4

A) before electrolysis

B) after 1 hour electrolysis at - 1mA

Conclusions

- H-absorption occurs without passing through adsorbed state
- Hydrogen diffuses directly into Pd bulk

$$H_3O^+ + e^- \rightarrow H_{abs} + H_2O$$

- Process speeds up when formation of adsorbed hydrogen layer is suppressed by the coverage of poisons

Our presence

• environmental viewpoint
millions of tons toxic gases released on every day
global warming

• economical viewpoint
strongly dependent on fossile fuels
oil, coal and gas price rises up

Our options

• solar energy
• wind power
• batteries and fuel cells
• nuclear power

What about cold fusion?

- Pons - Fleischmann experiment in 1989
  - long term electrolysis in a heavy water solution on plane palladium as electrode
- Research over the last 18 years
  - excess heat, nuclear transmutation, change of electrode surface morphology during long term electrolysis
  - not only restricted to Palladium but also occurs when nickel, gold etc. used as electrode

→ *Journal of New Energy, Fusion Information Centre, Salt Lake City*

Lack of reproducibility!!!

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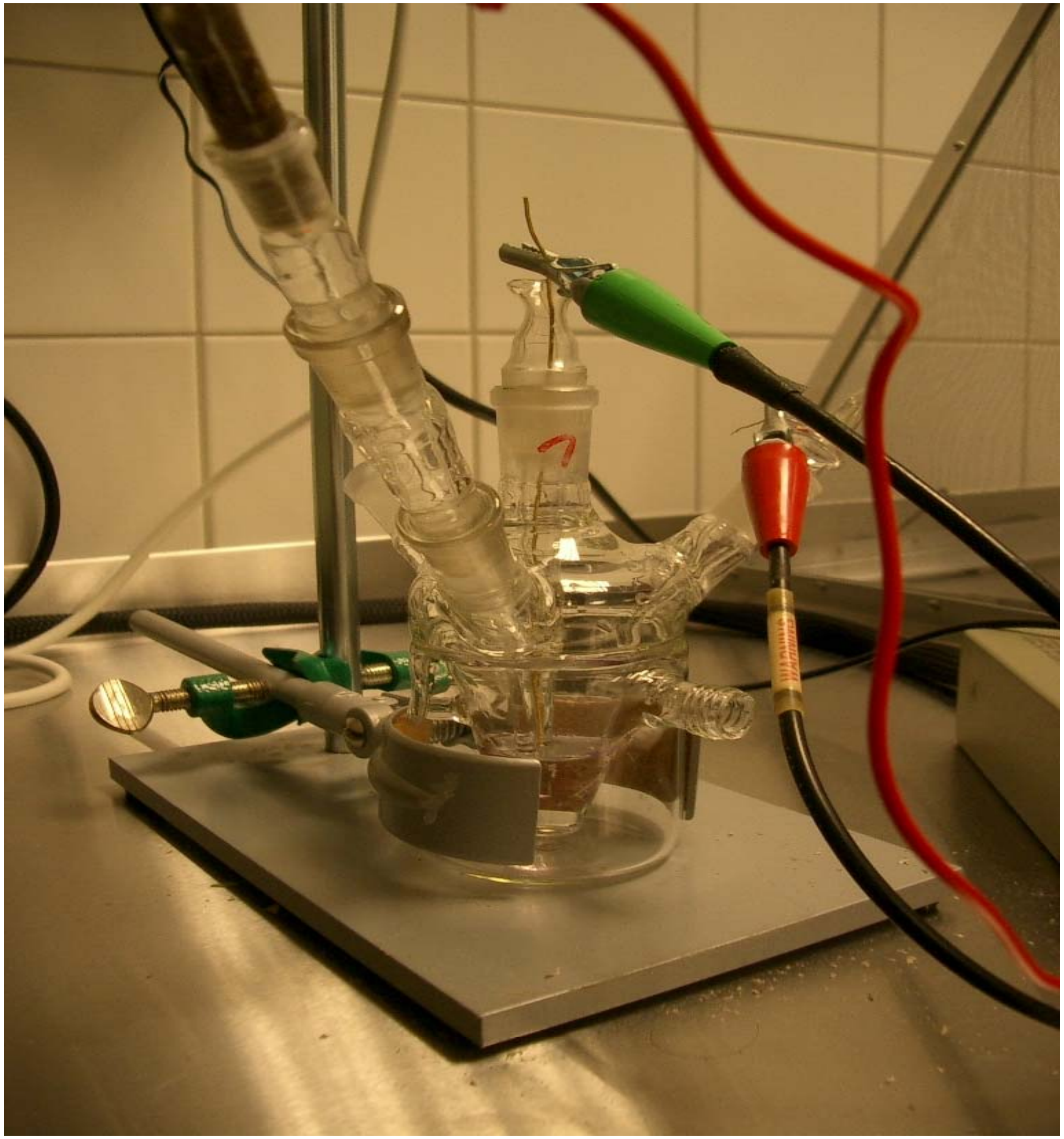
Electrochemical Cell



Experimental Evidence

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Coulomb Barrier Potential and Nuclear Forces - repulsion between nuclei

- recent physics and philosophy
- our scientific understanding
- What is the real world like?

↓

Strong need to re evaluate our scientific view

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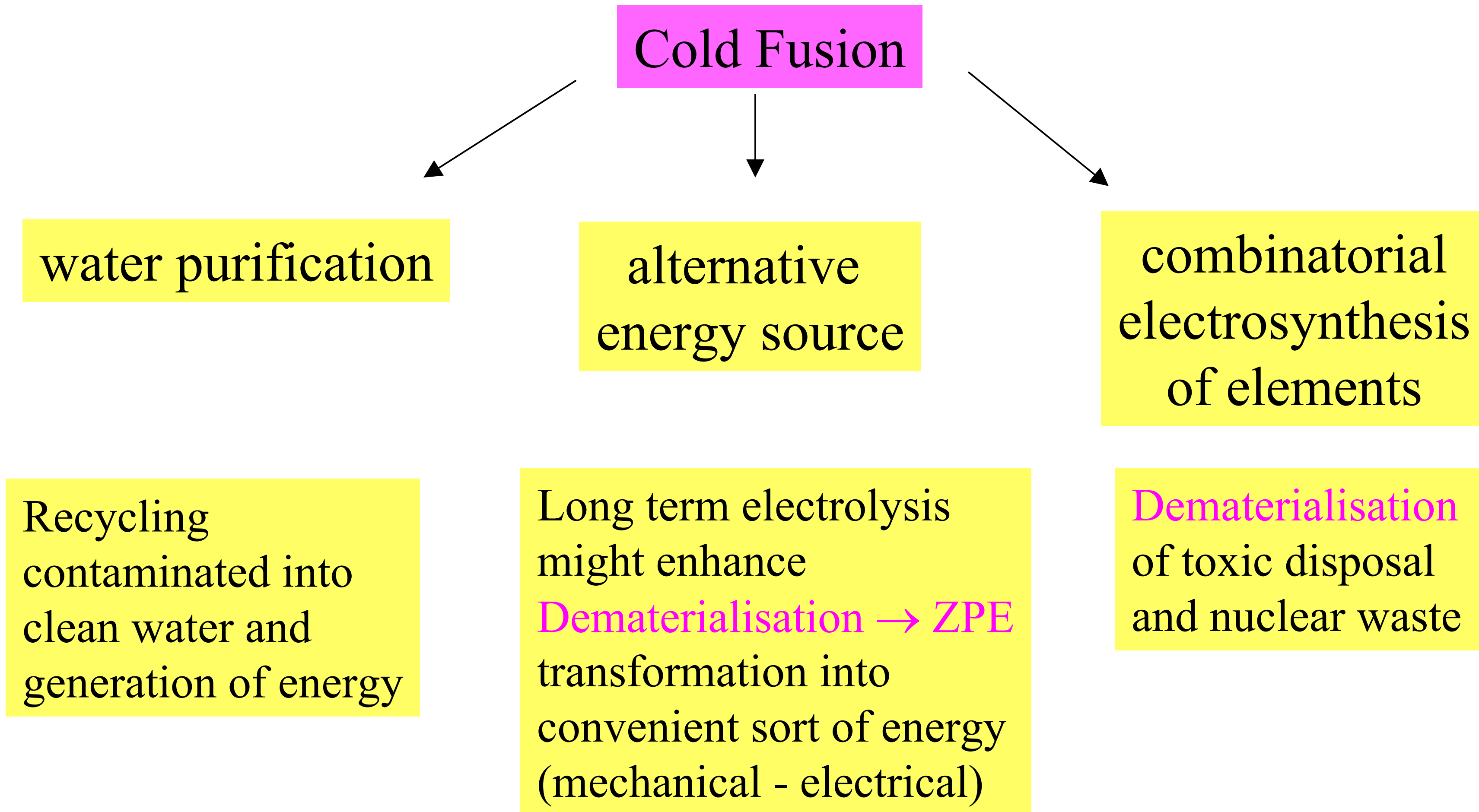
The New Science

Changing the PERSPECTIVE


Cold Fusion
water purification
alternative energy source
combinatorial electrosynthesis of elements
Recycling contaminated into clean water and generation of energy
Long term electrolysis might enhance Dematerialisation → ZPE transformation into convenient sort of energy (mechanical - electrical)
Dematerialisation of toxic disposal and nuclear waste