Hydrogen Contaminant Risk Assessment

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VTT
Fuel Cells & $\text{H}_2$
VTT IS
- the largest multitechnological applied research organisation in Northern Europe

VTT HAS
- polytechnic R&D covering different fields of technology from electronics to building technology
- clients and partners: industrial and business enterprises, organisations, universities and research institutes

- VTT Group turnover 188 M€ (2016)
- Personnel 2,440 (2016)
- 81% with university level degree
- 1,500 customers
- Established 1942
Fuel cells and hydrogen

Both low (PEM) and high temperature (SOFC) fuel cells
Hydrogen production (SOE) and hydrogen quality

Experimental work and modelling are combined extensively.

Modelling
- Multiphysical & data-based
- Static & dynamic
- Cell & stack & system level
PEMFC and H2

2 kW miniature automotive test bench for contaminant studies

Electric forklift installed with PEMFC triple-hybrid power source.

Single cell studies

Operation site of a 50 kW grid connected pilot plant in Äetsä.
Hydrogen Contaminant studies
Hydrogen Contaminant Risk Assessment

3-year EU project (FCH JU), 2014-17, coordinated by VTT

6 European partners, total budget of 3.907 M€.

The objectives of the project are

- to provide information to reduce cost of hydrogen fuel quality assurance (QA)

- to provide recommendations for revision of existing ISO 14687-2:2012 standard for hydrogen fuel in automotive applications

http://hycora.eu/deliverables.htm
Development of measurement methodology for unstable hydrogen fuel impurity studies

- HyCoRA strategy for cost reduction of H2 quality assurance (QA) – 
  Risk Assessment, qualitative and quantitative, requires information from

  a) Real susceptibility for various poisonous species specifically for automotive applications

  b) Probabilities for QA failure
     in hydrogen production site and/or at HRS

  a) Concentration correlations
     between contaminant species in fuel
Development of measurement methodology for unstable hydrogen fuel impurity studies

The logical tree studying the contaminants that poison the catalyst
Measurements with unstable H2 impurities

Unstable contaminants, such as HCHO/HCOOH, may not only to absorb to catalyst sites, but also

- Accumulate - into the H2 feed (recirculation system)
- Decompose - and form other, possibly harmful species
- Dissolve in water - and exit the system
- Permeate through Nafion membrane - e.g. membrane gas dryer in gas analysis loop
Measurements with unstable H2 impurities

- **Stack test station** + recirculation + GC
- PowercellS2 10-cell stack (SN025)
- Low anode loading MEA: 0,05 mg Pt/cm²
Impact of formaldehyde – stack measurements

- Two runs (4 and 3 hours) with ~1.6 ppm HCHO and 0.6 Acm⁻² using fuel utilisation of 99.5–99.6% (contaminant enrichment factor of 200-250)

- A very small (~ 10 mV) average voltage drop in 4 hours due to HCHO
  - In CO reference poisonings (1.86 ppm) :
    50 mV average voltage drop in 67-71 min

- Current limit for HCHO (ISO 14687-2:2012) is 0.01 ppm

- A large CH₄ increase (0 to 200 ppm) in anode recirculation loop
  → methanation of HCHO

- Some minor CO₂ increase/fluctuation in anode recirc loop. No changes in CO level.
Impact of formic acid – stack measurements

- Two runs (4 hours) with ~20 ppm HCOOH and 0.6 Acm⁻² using fuel utilisation of 99.5-99.6% (contaminant enrichment factor of 200-250)
- A very small (~ 5 mV) average voltage drop in 4 hours due to HCOOH
  - In CO reference poisonings 1.86 ppm leads 50 mV average voltage drop in ~70 min
- Current limit for HCOOH (ISO 14687-2:2012) is 0.2 ppm
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Thank you

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