New mechanism of copper corrosion?

Meeting with NWTRB
September 23, 2009
Willis Forsling
Known copper corrosion mechanisms

- There are a number of well-known corrosion mechanisms with e.g. sulfides, chlorides or carbonates in neutral aerobic aqueous solutions.
- Corrosion may also be induced by stress, granular imperfections and pitting.
2Cu(0) + HS\(^-\) + H\(^+\) \Rightarrow Cu\(_2\)S + H\(_2\)(aq)
2\text{Cu(s)} + \text{H}_2\text{O} + \text{CO}_2 + \text{O}_2 \Rightarrow \text{Cu}_2\text{(OH)}_2\text{CO}_3(\text{s})
Different types of local corrosion attacks on metals.
May copper corrode in pure water?

- Hydrogen evolution in corrosion of copper in pure water by G. Hultquist
  - Corrosion Science Vol 26 No 2 pp 173-177, 1986
  - Hydrogen was monitored with a solid electrolyte probe

- Comments on hydrogen evolution from the corrosion of pure copper
  - Corrosion Science Vol. 29, No 11/12 pp. 1371-1377, 1989
    G.Hultquist, G.K. Chuah, K.L. Tan
  - Hydrogen probe, SIMS
Recent studies on copper corrosion in anaerobic aqueous solutions?

  - $\text{Cu}(0) + y\text{H}_2\text{O} \rightarrow \text{H}_x\text{Cu}(I)\text{O}_y + (2y - x)\text{H}(0)\text{ads}$
  - $2\text{H}(0)\text{ads} + \text{O}(0)\text{ads} \rightarrow \text{H}_2\text{O}$
  - $2\text{H}(0) \rightarrow \text{H}_2(g)$

  - Conference contribution 2008
  - The mechanical properties of copper are found to be reduced
Experimental studies in deionized water at various temperatures

- Ion pump experiments to measure hydrogen production rate
- Pressure gauge experiment to measure hydrogen pressures
- Spectroskopic analyses of copper surfaces
- SIMS, XRD
The considerations of the Council

• Comments on the article *Corrosion of Copper by Water* by applying thermodynamic arguments.

• Meetings and discussions with the researchers (from KTH), the industry (SKB), the authority (SSM) and the environmentalists (MKG).

• Generating an independent review of relevant publications and reports on copper corrosion.

• Arranging an international work-shop on mechanisms of copper corrosion together with all the parties concerned.
Scientific workshop on Mechanisms of Copper Corrosion in Aqueous Environments

• In Stockholm on November 16, 2009

• Panel members
  – Gaik Khuan Chuah (National University of Singapore)
  – Ron Latanision (Massachusetts Institute of Technology)
  – Digby McDonald (Penn State University)
  – Dave Shoesmith (University of Western Ontario)

• Moderator
  – Rune Lagneborg (Royal Institute of Technology, Professor emeritus)
Abbreviation

- Royal Institute of Technology (KTH)
- Swedish Nuclear Fuel and Waste Management Co (SKB)
- Swedish Radiation Safety Authority (SSM)
- Swedish NGO Office for Nuclear Waste Review (MKG)