

New mechanism of copper corrosion?

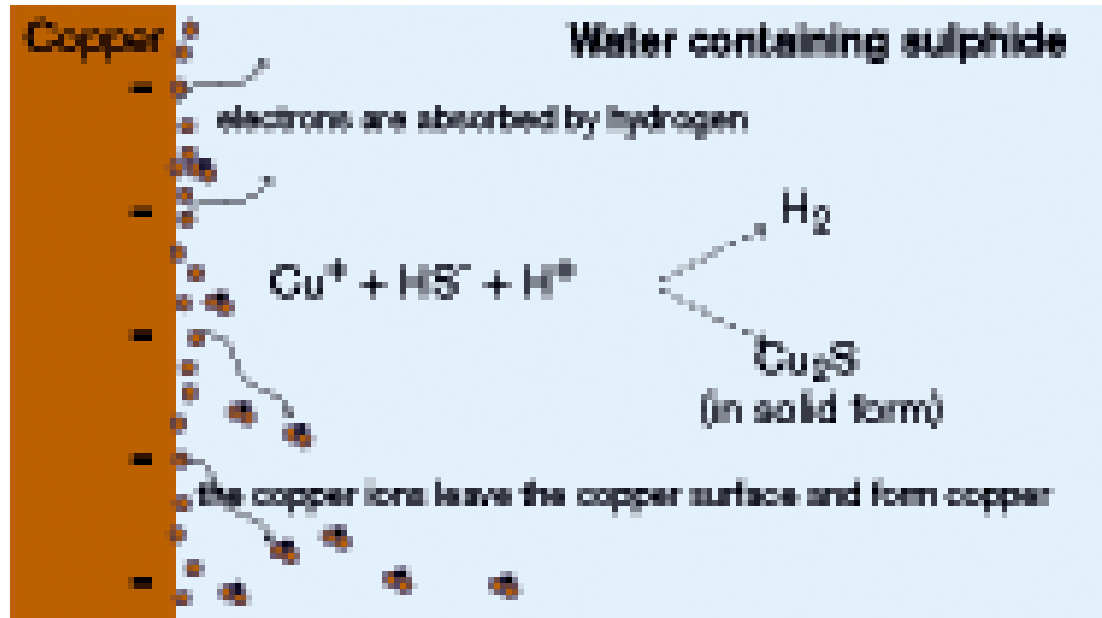
Meeting with NWTRB

September 23, 2009

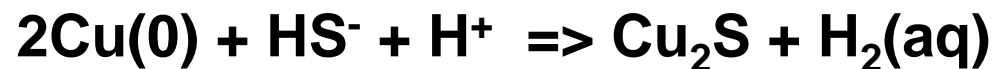
Willis Forsling

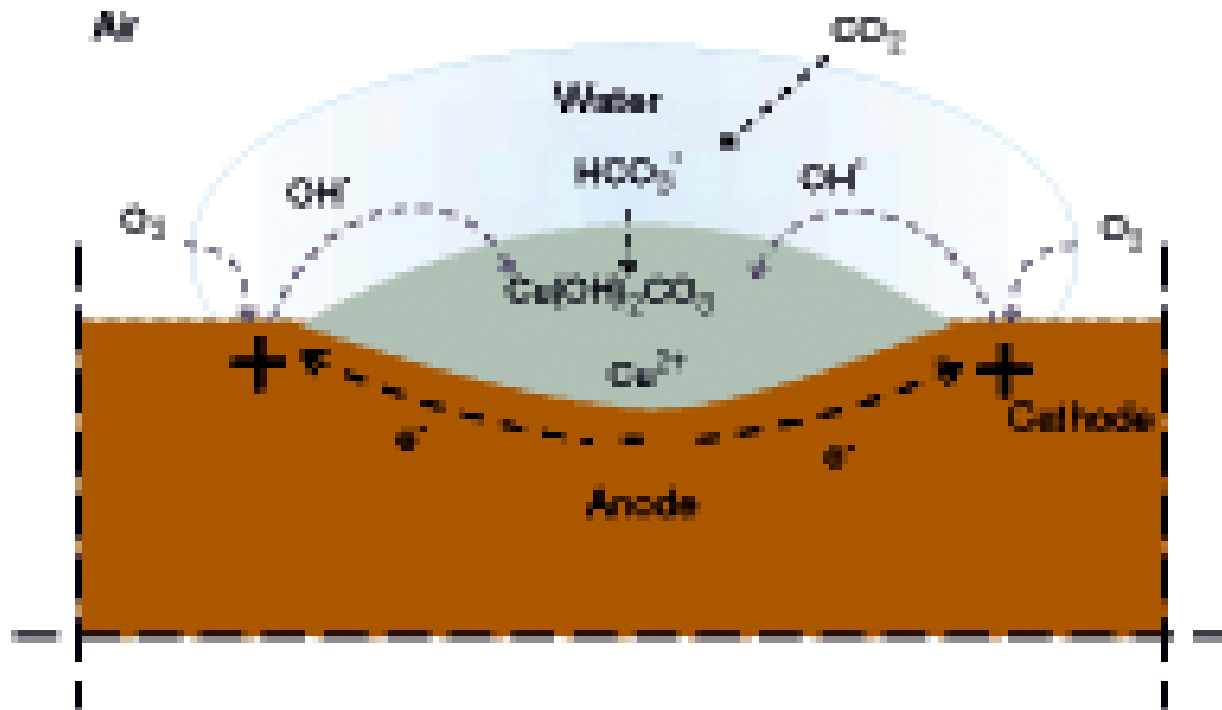
Known copper corrosion mechanisms

- 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.



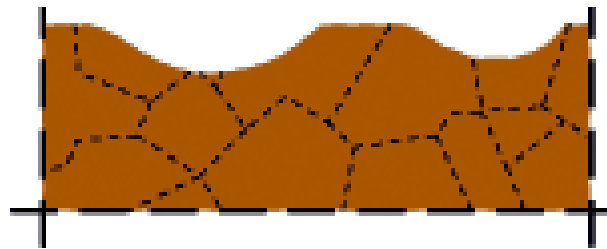
The copper ions nearest the surface form copper sulphide, which precipitates.





Corrosion cell beneath a water droplet on a patinated copper plate.





Pitting



Intergranular corrosion



Stress corrosion cracking

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?

- *Corrosion of Copper by Water*, Electrochemical and Solid-State Letters 10 (11) C63-C67 (2007), P.Szakalos, G.Hultquist, G.Wikmark
 - $\text{Cu}(0) + y\text{H}_2\text{O} \Rightarrow \text{H}_x\text{Cu}(\text{I})\text{O}_y + (2y - x)\text{H}(0)\text{ads}$
 - $2\text{H}(0)\text{ads} + \text{O}(0)\text{ads} \Rightarrow \text{H}_2\text{O}$
 - $2\text{H}(0) \Rightarrow \text{H}_2(\text{g})$
- *Detection of hydrogen in corrosion of copper in pure water* G.Hultquist, P.Szakalos, M.J.Graham, G.I.Sproule, G.Wikmark
 - 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
- Spectroscopic 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)