

CENTER FOR NUCLEAR WASTE REGULATORY ANALYSES

TRIP REPORT

SUBJECT: 2004 Gordon Research Conference on Aqueous Corrosion
Project Number 20.06002.01.011; AI 06002.01.011.016

DATE/PLACE: July 25–30, 2004
New London, NH

AUTHORS: Gustavo A. Cragolino

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AUTHORS: Gustavo A. Cragnolino

PERSONS PRESENT: G.A. Cragnolino (CNWRA), N. Sridhar and C.S. Brossia (SwRI),
and approximately 120 attendees (list attached)

BACKGROUND AND PURPOSE OF TRIP:

The Gordon Research Conference on Aqueous Corrosion is held on alternate years to bring leading researchers in the field together to discuss recent advances in chemical, electrochemical, surface science, and metallurgical aspects of corrosion and/or corrosion prevention in aqueous environments. The conferences emphasize informal interactions, and in this spirit no formal proceedings or abstracts are issued. In addition to the oral presentation by invited speakers, about 50 poster presentations were in display. The purpose of the trip was to participate in the discussions and obtain an understanding of the state of corrosion science and research techniques in topics of relevance to high level waste repository performance and other related areas. The author was personally invited to participate by the chair of the conference, John Scully (University of Virginia).

SUMMARY OF PERTINENT POINTS:

This year's conference included presentations on: (i) *in-situ* and *ex-situ* studies of corrosion; (ii) oxide films and surface modification; (iii) detection, prediction, and simulation of pitting corrosion; (iv) transitions of pits to stress corrosion cracks; (v) modeling and simulation of corrosion processes; (vi) mechanisms of corrosion inhibition by coatings and additives; (vii) microstructural aspects of corrosion; and (viii) nanoscale aspects of corrosion.

The opening session focused on *in-situ* and *ex-situ* studies of corrosion using radioactive labeling and spectroscopic techniques. A. Wieckowski (University of Illinois at Urbana-Champaign) discussed studies on aluminum alloy corrosion (mostly A2024-T3) using *in-situ* radioactive labeling which generates beta-radiation for the characterization of adsorbed species that could act as inhibitors. He discussed in some detail the use of *ex-situ* ultra high vacuum spectroscopy, in particular X-ray photoelectron spectroscopy and Auger electron spectroscopy to study the interaction of chromates with copper-rich intermetallic particles in inhibiting localized corrosion in chloride solutions. The second presentation was on *in-situ* studies of the metal/atmosphere interfacial regime by C. Leygraf (Royal Institute of Technology, Sweden). This presentation introduced to the attendees the use of vibrational sum frequency spectroscopy (VSFS) as a powerful tool to study interfacial structures at the molecular level. VSFS uses two pulsed laser beams, one at a fixed visible frequency and the other tunable in the infrared region. The beams overlap in time and space at the interface and a third beam with the

sum frequency of the two incident beams is emitted. Sum frequency generation can be seen as a combination of Raman and infrared processes. The technique permits the detection of molecules on an interface finding what is the preferred orientation. Leygraf described the application of the technique to the study of the liquid/vapor interface in aqueous acetic acid solutions because acetic acid is an important species accelerating corrosion in many indoor atmospheres.

K. Zavadil (Sandia National Laboratories) discussed the nano-scale evolution of passive oxide films on aluminum and the role of the passive film in determining the nucleation of metastable and stable pits. He used Time of flight-Secondary ion mass spectroscopy (TOF-SIMS) to probe the metal surface and evaluate the oxide film thickness as a function of time. Voids in the film were identified by transmission electron microscopy using phase contrast. However, it was found that only a very small fraction of the voids evolved as pores and only 10 percent of them evolved into pits. M. Stratmann (Max Planck Institute for Iron Research, Germany) made an interesting presentation on the use of tailored semiconducting oxides for improving the corrosion resistance and adhesion of organic coatings.

S. Brossia (SwRI) made a presentation on sensors, methods and models for the investigation and prediction of localized corrosion in which novel approaches to the design of sensors based on integrated circuits using miniature power cells were discussed. A presentation by Nick Laycock (Materials Performance Technologies, New Zealand) on numerical simulation of pitting corrosion followed. Three stages of pitting were identified by Laycock: nucleation, initiation and propagation. Nucleation was distinguished from initiation as related to the nucleation of oxide imperfections or micropits that were metastable and repassivate in a large proportion. The small fraction that nucleates must reach a critical size, characterized by a modification of the Galvele's criterion that the product of the current density by the depth should be equal to a critical value. This modification was introduced because Laycock considered variations in pit morphology. Pit propagation was defined in terms of the well established power law in which the penetration is proportional to the square root of time.

A. Turnbull (National Physical Laboratory, United Kingdom) made an interesting presentation in which the conditions for the transition from pits to cracks were discussed. He described in detail a laborious technique of metal removal to follow such transition and presented an statistical analysis of the distribution of pits giving raise to cracks as a function of pit depths. Unfortunately, the study was confined to low alloy (Ni-Cr-Mo-V) steels used as steam turbine materials in chloride plus sulfate solutions and the conclusions may be different for more alloyed materials.

There were other interesting presentations. One of them by J. Earthman (University of California at Irvine) discussed the role in many situations of corrosion inhibiting biofilms that could mitigate the occurrence of microbially influenced corrosion. A. Gerwith (University of Illinois at Urbana—Champaign) presented an excellent talk on the use of VSFS to analyze the effect of additives on corrosion through the detailed study of the metal/solution interface in the case of copper/benzotriazole (BTA) and the adsorption of water molecules to noble metal surfaces in the presence of anionic species such as halides. H. White (University of Utah) made also an excellent presentation on electrochemistry in nanoscale domains, describing techniques for studying electrochemical reactions that can be implemented in miniature sensors for a variety of applications.

J. Payer (Case-Western Reserve University) made an unscheduled presentation based on the one done at the 2004 Spring Meeting of the Nuclear Waste Technical Review Board. His presentation was useful to provide to the audience an overview of the current status of U.S. Department of Energy (DOE) studies on waste package corrosion and promoted an interesting discussion that unfortunately ran short of time. Investigators from the Idaho National Engineering Environment Laboratory (INEEL) had a poster on passivity and localized corrosion of a Ni-15Cr-15Mo-2.4Gd alloy. This alloy, loosely based on the composition of alloy 22, was developed in INEEL as an appropriate alloy to be used as neutron absorber in DOE highly enriched spent fuel waste packages instead of borated stainless steel. The authors claimed that despite the existence of an intermetallic $(\text{Ni,Cr})_5\text{Gd}$, which tends to dissolve preferentially in dilute, acidic chloride solutions at passive potentials, the alloy is far more resistant to corrosion than boron-containing Type 304 stainless steel. This is the neutron absorbing material currently used in racks for wet spent fuel storage at nuclear power plants.

IMPRESSION/CONCLUSIONS:

The meeting was mostly attended by members of the academic institutions and research laboratories. Compared with other years, representation from national laboratories was rather limited. A presenter from Los Alamos National Laboratory was replaced at the last moment because he could not attend due to the current situation in that laboratory. The discussions after each presentation were extensive, enlightening, and lively. These discussions provided ideas for future investigations and the use of new techniques to evaluate container life and develop concepts for performance confirmation activities. Discussions with J. Payer allowed the author to learn the scope and extension of the DOE Science and Technology program in the area of waste package corrosion which will be carried out in the next 5 years. In this program several well known university laboratories will play the dominant role because it appears that DOE realizes that a more solid fundamental understanding and technical basis are needed to support many assumptions contained in models, specially when they are based on limited experimental data. Philippe Marcus (University Pierre and Marie Curie, Paris, France), the current vice-chair, will be the chair of the next Conference and Alison Davenport (University of Birmingham, United Kingdom) was elected by secret ballot of the attendees as the next vice-chair.

PROBLEMS ENCOUNTERED:

None.

PENDING ACTIONS:

None.

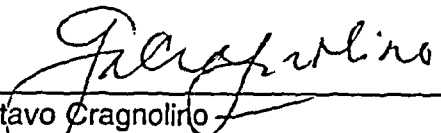
RECOMMENDATIONS:

Attendance to the next conference, scheduled for July 2006, is highly recommended to become aware of recent development in corrosion science and technology. It will be useful to get more information on the DOE Science and Technology program. Findings in this program could be implemented by the DOE as improvements in designs, corrosion models, and performance confirmation activities.

ATTACHMENT:

An agenda of the meeting and the list of attendees are attached.


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8/10/2004
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Attachment

GC:jg

Corrosion - Aqueous

July 25-30, 2004
Colby-Sawyer College
New London, NH

Chair: John R Scully
Vice Chair: Philippe Marcus

ABSTRACT

The Gordon Research Conference on Aqueous Corrosion provides a forum for presentation of the latest advances in corrosion research with a particular emphasis on chemical, electrochemical, surface science and metallurgical aspects of corrosion and/or corrosion prevention in environments containing water. The Conference brings together the leading scientists from academia, industry and government labs to discuss current research directions and themes at Colby-Sawyer College, an outstanding venue for scientific interaction and recreation. In addition to oral presentations, the Aqueous Corrosion Conference has highly valued poster sessions. The majority of attendees presents either a talk, a poster or serves as a discussion leader.

In addition, a late-breaking session of oral presentations will be selected from submitted poster abstracts. The Aqueous Corrosion Conference provides a unique opportunity to examine the breadth of Aqueous Corrosion in a small meeting format that encourages in-depth discussion among the attendees.

All scientists with an interest in corrosion phenomena and science are encouraged to apply to attend the Aqueous Corrosion Conference. The organizers are committed to achieving a balance among the attendees in terms of career stage, gender, nationality and area of interest.

SUNDAY

- 2:00 pm - 9:00 pm Arrival and check-in
4:00 pm - 6:00 pm Poster Session 1 (Philippe Marcus / poster presenters)
6:00 pm Dinner
7:30 pm - 9:30 pm **IN-SITU and EX-SITU STUDIES OF CORROSION**
 Discussion Leader: M. Graham (National Research Council, CANADA)
7:30 pm - 8:30 pm Andrzej Wieckowski (University of Illinois, USA)
 "Strategies in Studies of Aluminum Alloy Corrosion/Protection"
8:30 pm - 9:30 pm Christofer Leygraf (Royal Institute of Technology, SWEDEN)
 "In-Situ Studies of the Metal/Atmosphere Interfacial Regime"

MONDAY

- 7:30 am - 8:30 am Breakfast
9:00 am - 12:30 pm **OXIDE FILMS and SURFACE MODIFICATION**
 Discussion Leader: Digby Macdonald (Pennsylvania State University, USA)
9:00 am - 10:00 am Kevin Zavadil (Sandia National Laboratories, USA)
 "Nano-scale Evolution of Passive Oxide Structure and Composition on Aluminum:
 Defining the Role of the Oxide in Determining Meta-stable and Stable Pit Formation"
10:00 am Coffee Break / Photo
10:30 am - 11:30 am Martin Stratmann (Max-Planck-Institut für Eisenforschung, GERMANY)
 "Surface Modification of Iron and Aluminium Based Alloys for Improved Corrosion
 Resistance and Adhesion"
12:30 pm Lunch
1:30 pm - 4:00 pm Free Time

- 4:00 pm - 6:00 pm Poster Session 2 (John Scully / poster presenters)
 6:00 pm Dinner
 7:30 pm - 9:30 pm **DETECTION, PREDICTION and SIMULATION OF PITTING**
 Discussion Leader: Hugh Isaacs (Brookhaven National Labs, USA)
 7:30 pm - 8:30 pm Sean Brossia (Southwest Research Institute, USA)
 Investigation of Localized Corrosion Processes Using Novel Sensors, Methods, and Models
 8:30 pm - 9:30 pm Nick Laycock (Materials Performance Technologies, NEW ZEALAND)
 Numerical Simulation of Pitting Corrosion
- TUESDAY**
 7:30 am - 8:30 am Breakfast
 9:00 am - 12:30 pm **TRANSITIONS FROM PITS TO CRACKS**
 Discussion Leader: Roger Staehle (Consultant, USA)
 9:00 am - 10:00 am Alan Turnbull (National Physical Laboratories, UK)
 Characterising the Evolution of Pits and Cracks in Steam Turbine Disc Steels
 10:00 am Coffee Break
 10:30 am - 11:30 am R. Winston Revie (CANMET Materials Technology Lab., CANADA)
 SCC and HIC Initiation In Linepipe Steels: The Role of Inclusions and Pits
 12:30 pm Lunch
 1:30 pm - 6:00 pm Free Time
 6:00 pm Dinner
 7:30 pm - 9:30 pm **MODELING and SIMULATION OF CORROSION PROCESSES**
 Discussion Leader: David Shoesmith (University of Western Ontario, CANADA)
 7:30 pm - 8:30 pm Matt Neurock (University of Virginia, USA)
 Multi-Scale Modeling of Electrochemical Systems: Challenges and Opportunities
 8:30 pm - 9:30 pm William Curtin (Brown University, USA)
 Multi-Scale Modeling of H Embrittlement in Metals
- WEDNESDAY**
 7:30 am - 8:30 am Breakfast
 9:00 am - 12:30 pm **MECHANISMS OF CORROSION INHIBITION: ADDITIVES**
 Discussion Leader: Jerry Frankel (Ohio State University, USA)
 9:00 am - 10:00 am Maria Forsyth (Monash University, AUSTRALIA)
 Synergistic Corrosion Inhibition Associated with REM-Carboxylate Compounds
 10:00 am Coffee Break
 10:30 am - 11:30 am Andrew Gewirth (University of Illinois at Urbana-Champaign, USA)
 Effect of Additives On Deposition and Corrosion: Vibrational Spectroscopic Measurements
 12:30 pm Lunch
 1:30 pm - 6:00 pm Free Time
 6:00 pm Dinner
 7:30 pm - 9:30 pm **MECHANISMS OF CORROSION INHIBITION: COATINGS**
 Discussion Leader: Martin Kendig (Rockwell International Science Center, USA)
 7:30 pm - 8:30 pm Neil McMurray (University of Wales-Swansea, UK)
 Mechanisms of Corrosion Inhibition by Polyaniline and Ion-Exchange Pigments
 8:30 pm - 9:30 pm James Earthman (University of California, USA)
 Corrosion Inhibiting Biofilms
- THURSDAY**
 7:30 am - 8:30 am Breakfast
 9:00 am - 12:30 pm **MICROSTRUCTURAL ASPECTS OF CORROSION**

Discussion Leader: Roger Newman (UMIST, UK)
9:00 am - 10:00 am Sean Corcoran (Virginia Polytechnic and State University, USA)
"Dealloying: An Old Problem with New Potential"
10:00 am Coffee Break
10:30 am - 11:30 am Scott Lillard (Los Alamos National Laboratory, USA)
"Do Metal-Metal Bonds Control Dissolution During Crystallographic Pitting?"
12:30 pm Lunch
1:30 pm - 6:00 pm Free Time
6:00 pm Dinner
7:30 pm - 9:30 pm **NANOSCALE ASPECTS OF CORROSION**
Discussion Leader: Karl Sieradzki (Arizona State University, USA)
7:30 pm - 8:30 pm Henry White (University of Utah, USA)
"Electrochemistry in Nanoscale Domains"
8:30 pm - 9:30 pm Mary Ryan (Imperial College London, UK)
"Effects of Nanocrystallinity in Corrosion and Passivation"
FRIDAY
7:30 am - 8:30 am Breakfast
9:00 am Departure

IMPORTANT NOTE: The 2004 Democratic National Convention will be held in Boston, Massachusetts from July 26-29 (the same week as this meeting). Attendees should make their reservations early to avoid the high costs and flights being sold out.



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Last Updated: 5/6/04 by [Jeff Carroll](#)

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