CMD
2026
Conference

# The 3rd International Online Conference on Corrosion and Materials Degradation

30 June–2 July 2026 | Online

Program and Abstract Book

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#CMD2026


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# The 3rd International Online Conference on Corrosion and Materials Degradation

## In Memoriam of Prof. Dr. Digby Macdonald

**30 June–2 July 2026 | Online**

MDPI

# Organizing Committee

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Prof. Dr. David Bastidas
Prof. Dr. Dominique Thierry
Prof. Dr. Mirna Urquidi-Macdonald

## Session Chairs

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Dr. María Criado Sanz
Dr. Sviatlana Lamaka
Dr. Viswanathan S. Saji
Prof. Alankar Alankar
Prof. Dr. Angeliki G. Lekatou
Prof. Dr. David Bastidas
Prof. Dr. Frank Cheng
Prof. Dr. Homero Castaneda
Prof. Dr. Kiryl A. Yasakau
Prof. Dr. Nick Birbilis

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## Organizing Team

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# Welcome from the Chairs

Dear Colleagues,

It is our sincere pleasure and great honor to announce **the 3rd International Online Conference on Corrosion and Materials Degradation** (CMD 2026), following the two successful preceding conferences, the 1st Corrosion and Materials Degradation Web Conference and the 2nd Corrosion and Materials Degradation Web Conference. This edition will once again be hosted online by the MDPI open access journal ***Corrosion and Materials Degradation (CMD)*** (ISSN: 2624-5558; Impact Factor: 2.7; Cite Score: 4.3) from 30th June to 2nd July 2026.

The CMD 2026 will render tribute to our esteemed Prof. Digby Macdonald, who was a founding editorial board member of the Corrosion and Materials Degradation journal, and a pioneer in the application of electrochemical methods and theories to advancing the understanding of corrosion and materials degradation. His remarkable and seminal work left a lasting mark on the field of electrochemistry and has been a continuous inspiration and legacy for the current and future generations of researchers in corrosion and materials science, and engineering. He delivered novel approaches and original contributions across a wide array of interdisciplinary subjects, particularly focusing on corrosion and interfacial electrochemical processes on materials in a wide range of applications, including nuclear energy, infrastructure, and transportation, among others. Digby's accolades have been recognized for his talent in designing rigorous, illuminating experiments and for crafting predictive theoretical models at the frontiers of knowledge grounded in core scientific first principles.

Corrosion and the science and technology of its mitigation are like an antique but fascinating subject. It is among the most common forms of material degradation, which poses enormous challenges across industries, and it can even impact our health. The vexing problem of corrosion continues to negatively affect our society, but it also brings about the application of new and critical technologies. CMD 2026 will present disruptive and novel approaches to corrosion mitigation for commercially attractive exploitation while also promoting the cutting-edge advancements of the traditional approaches of the discipline.

All corrosion scientists or engineers and those associated with the mechanical degradation of materials are welcome to join this event and share their findings around the following general and related themes. However, the list is not exclusive.

S1. Electrochemical Corrosion Mechanism at the Interface (Localized, Crevice, Advanced Characterization Techniques, EAC, Nanoscale);
S2. Corrosion of Steel in Concrete;
S3. Surface Treatments and Coatings for Corrosion Protection;
S4. Corrosion in New Materials (HEA, CCA, TWIP/TRIP, AM, PM);
S5. Corrosion in Biomedical Implants;
S6. Corrosion and Integrity Management in Energy Infrastructure;
S7. Discovery and Application of Corrosion Inhibitors;
S8. AI and ML Tools and Digital Twins for Corrosion Prediction.

CMD 2026 will allow you to share and discuss your most recent research findings with a vibrant worldwide community of scientists and engineers in the field. Moreover, numerous internationally renowned speakers will share their current state-of-the-art research during the conference through three live sessions, including comprehensive Q&A sessions.

The conference features two presentation formats: oral (15-minute session including Q&A) and poster (display online in poster gallery). Submitted abstracts will be reviewed by the conference

committee. All accepted abstracts will be available for registered participants in the form of a book of abstracts during the conference period. Attendees are also warmly encouraged to submit full manuscripts to the Special Issue of *Corrosion and Materials Degradation (CMD)* (ISSN: 2624-5558; Impact Factor: 2.7; Cite Score: 4.3), benefiting from a 20% publication fee discount. All submissions will follow MDPI's standard peer-review process.

We look forward to having you join us at this exciting event.

Kind regards,
**Prof. Dr. Raman Singh**
Monash University, Australia
**Prof. Dr. Mirna Urquidi-Macdonald**
Pennsylvania State University, USA
**Prof. Dr. David M. Bastidas**
Deakin University, Australia
**Prof. Dr. Dominique Thierry**
RISE Research Institutes, Sweden
**The Chairs of the 3rd International Online Conference on Corrosion and Materials Degradation**

**Prof. Dr. Raman Singh**

Department of Chemical and Biological Engineering and Department of Mechanical and Aerospace Engineering, Monash University, Australia

**Prof. Dr. David Bastidas**

School of Engineering Faculty of Science, Engineering and Built Environment, Deakin University, Australia

**Prof. Dr. Dominique Thierry**

RISE Research Institutes, Sweden

**Prof. Dr. Mirna Urquidi-Macdonald**

Department of Engineering Science and Mechanics, Pennsylvania State University, USA

*corrosion and materials degradation*
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*Corrosion and Materials Degradation* (ISSN 2624-5558) an age-old and vexing problem continues to attract research attention, not only because it continues to cost our society very dearly but also for its bearings on application of new and critical technologies. For example, whether it is use of magnesium alloys as novel biodegradable temporary implants, or material for nuclear waste containers, desalination plants or durable electronic devices, corrosion often stands out as a non-trivial challenge. It is true that circumventing corrosion in such critical applications is technologically challenging, socially fulfilling as well as commercially attractive, but it is equally true that a durable solution calls for a disruptive approach, which in itself is a non-trivial challenge (given the age-old nature of the discipline). On the other hand, given the huge economic losses caused by corrosion, the emergence of a new material often triggers an interest in its applicability for corrosion resistance. Most recent examples include ultrathin coatings of graphene and hexa-boron nitride. Corrosion, and science and technology of its mitigation, therefore, is like an antique, old but fascinating.

The proposed journal has the core objective of providing a new platform for dissemination of disruptive and novel approaches to corrosion mitigation for commercially attractive exploitation, whereas promoting also the cutting-edge advancements of the traditional approaches of the discipline.

**Impact Factor:** https://www.mdpi.com/journal/cmd

# Session Chairs

**Prof. Dr. David Bastidas**

School of Engineering
Faculty of Science, Engineering and Built Environment,
Deakin University, Australia

**Dr. María Criado Sanz**

Eduardo Torroja Institute for Construction Sciences (IETcc), Spanish Research Council (CSIC), Madrid, Spain

**Prof. Dr. Andrés Moya**

Department of Civil, Chemical, Environmental and Materials Engineering (DICAM), University of Bologna, Bologna, Italy

**Dr. Viswanathan S. Saji**

Interdisciplinary Research Center for Advanced Materials, King Fahd University of Petroleum and Minerals (KFUPM), Dhahran, Saudi Arabia

**Dr. Kiryl A. Yasakau**

Department of Materials and Ceramic Engineering and CICECO - Aveiro Institute of Materials, University of Aveiro, Aveiro, Portugal

**Prof. Dr. Homero Castaneda**

Materials Science and Engineering Department, National Corrosion and Materials Reliability Center, Texas A&M University, College Station, USA

**Prof. Dr. Angeliki G. Lekatou**

Faculty of Science, University of Western Australia, Perth, Australia

**Dr. Sviatlana Lamaka**

Department of Electrochemistry and Big Data, Helmholtz-Zentrum Hereon, Geesthacht, Germany

**Prof. Dr. Nick Birbilis**

Department of the Science, Engineering and Built Environment, Deakin University, Victoria, Australia

**Prof. Dr. Frank Cheng**

Department of Mechanical and Manufacturing Engineering, University of Calgary, Calgary, AB, Canada

**Prof. Alankar Alankar**

Department of Mechanical Engineering, Indian Institute of Technology Bombay, Mumbai, India

# Keynote Speakers

**Prof. Dr. Mirna Urquidi-Macdonald**

Department of Engineering Science and Mechanics, Pennsylvania State University, USA

**Prof. Dr. Ramón Nóvoa**

University of Vigo, School of Industrial Engineering, University Campus, Vigo, Spain

**Prof. Dr. Robert Melchers**

School of Engineering (Civil Engineering), The University of Newcastle, Newcastle, Australia

**Prof. Dr. Roger Newman**

Department of Chemical Engineering and Applied Chemistry, University of Toronto, Toronto, Canada

**Prof. Dr. Rhys Jones**

1. Department of Mechanical and Aerospace Engineering, Monash University Clayton, Clayton, Australia
2. ARC Industrial Transformation Training Centre on Surface Engineering for Advanced Materials, Faculty of Science, Engineering and Technology, Swinburne University of Technology, Hawthorn, Australia

**Prof. Dr. Jing-Li Luo**

Department of Chemical and Materials Engineering, University of Alberta, Edmonton, Alberta, Canada

**Prof. Dr. Tom Depover**

Research Group Sustainable Materials Science (SMS), Ghent University, Ghent, Belgium

**Prof. Dr. Ueli Angst**

The Durability of Engineering Materials Group, Institute for Building Materials (IfB), ETH Zurich, Zurich, Switzerland

# Invited Speakers

**Prof. Dr. Liang Wu**

1 College of Materials Science and Engineering, Chongqing University, Chongqing, China
2 National Engineering Research Center for Magnesium Alloys, Chongqing University, Chongqing, China
3 Chongqing Institute of New Energy Storage Materials and Equipment, Chongqing, China

**Dr. Frederico Maia**

Smallmatek - Small Materials and Technologies, Lda, Aveiro, Portugal

**Professor Raghu Srinivasan**

Department of Mechanical Engineering, University of Alaska Anchorage, Anchorage, USA

**Prof. Dr. Rajeev Kumar Gupta**

Department of Material Science and Engineering, North Carolina State University, Raleigh, USA

**Prof. Dr. Vasily Efremenko**

Department of Physics, Pryazovskyi State Technical University, Mariupol, Ukraine

**Prof. Dr. Rob Lindsay**

School of Materials, The University of Manchester, UK

**Professor Di Mei**

School of Materials Science and Engineering & Zhongyuan Critical Metals Laboratory, Zhengzhou University, Henan, China

**Dr. Matic Poberžnik**

Department of Physical and Organic Chemistry, Jožef Stefan Institute, Ljubljana, Slovenia

**Professor Florin Bobaru**

Department of Mechanical and Materials Engineering, University of Nebraska, Lincoln, United States

**Dr. Xiaolei Guo**

Department of Metallurgical and Materials Engineering, Colorado School of Mines, CO, USA

**Dr. Rebecca Filardo Schaller**

Sandia National Laboratory, Albuquerque, USA

**Dr. Dev Chidambaram**

Materials Science and Engineering. University of Nevada, Reno, NV, USA

**Dr. Damien Féron**

Corrosion Research and Materials Behavior Service, Université Paris-Saclay, CEA, Gif-sur-Yvette, France

**Professor Simeon Agathopoulos**

Materials Science & Engineering Department, School of Engineering, University of Ioannina, Greece

# Program Overview

| CMD2026 | 30 June 2026 | 1 July 2026 | 2 July 2026 |
|---|---|---|---|
| **MORNING SESSION** 09:00 CEST * DAY 1 08:00 CEST | **Session 3.** Surface Treatments and Coatings for Corrosion Protection | **Session 5.** Corrosion in Biomedical Implants | **Session 7.** Discovery and Application of Corrosion Inhibitors |
| | **Session 2.** Corrosion of Steel in Concrete **Parallel Session** | **Session 1.** Electrochemical Corrosion Mechanism at the Interface (part 1) | Flash Poster Session |
| **AFTERNOON SESSION** 14:00 CEST | **Session 6.** Corrosion and Integrity Management in Energy Infrastructure | **Session 1.** Electrochemical Corrosion Mechanism at the Interface (part 2) | **Session 8.** AI and ML Tools and Digital Twins for Corrosion Prediction |
| | | | **Session 4.** Corrosion in New Materials (HEA, CCA, TWIP/TRIP, AM, PM) |

# CMD2026 Program

## 30th June 2026 (Tuesday)

### *Session 3. Surface Treatments and Coatings for Corrosion Protection (Morning Session)*

***Time: 08:00 (CEST, Basel) | 02:00 (EDT, New York) | 14:00 (CST, Beijing)***

| Time in CEST | Speaker | Title |
|---|---|---|
| 8:00–8:10 | Conference Chair<br>Welcome from the Conference Chair | |
| 8:10–8:15 | Dr. Viswanathan S. Saji &<br>Dr. Kiryl A. Yasakau<br>Welcome from the Session Chairs | |
| 8:15–8:40 | **Prof. Dr. Liang Wu**<br>Invited Speaker | Research Progress on LDHs@MXene Self-healing Composite Coatings |
| 8:40–9:05 | **Dr. Frederico Maia**<br>Invited Speaker | Layered double hydroxides as a versatile approach to protect metallic surfaces |
| 9:05–9:20 | **Luca Pezzato**<br>Selected Oral Speaker | Corrosion Resistance and Functional Properties of Particle-Modified Plasma Electrolytic Oxidation Coatings on Metals |
| 9:20–9:35 | **Stanley Ofoegbu**<br>Selected Oral Speaker | Towards an Easy Electrochemical Method for Evaluating Sealing Quality of Anodized Aluminium |
| 9:35–9:50 | **Mihaela Dinu**<br>Selected Oral Speaker | Corrosion protection of AZ31B magnesium alloy using Ti-Zr thin films for biodegradable implant applications |
| 9:50–10:05 | **Ozen Nisa Turkmen**<br>Selected Oral Speaker | A Comparison of Anti-Corrosive Performances of Phenolic-, Urethane-, THEIC-, Epoxy- and Silicone-Modified Alkyd Resins |
| 10:05–10:20 | **Maria Pastrafidou**<br>Selected Oral Speaker | Multifunctional Ionic Polymer Coatings with Self-Healing and Photocatalytic Activity for Aluminum Alloy Corrosion Protection |
| 10:20–10:35 | **Marandela Mulaudzi**<br>Selected Oral Speaker | Investigation of Binary and Ternary Ni-Based Alloys for High-Temperature Petrochemical Coating Applications |
| 10:35–10:50 | **Aylin Ahmadinia**<br>Selected Oral Speaker | A Sustainable Multi-Layer Anti-Corrosion Strategy for Magnesium Using a Surfactant to Strengthen Interlayer Adhesion |
| 10:50–11:05 | **Adam Goff**<br>Selected Oral Speaker | Blockade GC: A Non-Chrome Galvanic Corrosion Protective Coating for the Future |
| 11:05–11:20 | **Ahnaf Sadi**<br>Selected Oral Speaker | Nanosecond Laser Texturing of Triple-Scale Surface Structuring for Robust Pitting Corrosion Resistance in AA6061 |

### *Session 2. Corrosion of Steel in Concrete (Morning Parallel Session)*

***Time: 09:00 (CEST, Basel) | 03:00 (EDT, New York) | 15:00 (CST, Beijing)***

| Time in CEST | Speaker | Title |
|---|---|---|
| 9:00–9:05 | Dr. María Criado Sanz &<br>Dr. Giulia Masi<br>Welcome from the Session Chairs | |
| 9:05–9:40 | **Prof. Dr. Ueli Angst**<br>Keynote Speaker | Advances in imaging corrosion of steel in concrete and implications for degradation mechanisms |
| 9:40–9:55 | **Siaw Foon Lee**<br>Selected Oral Speaker | Corrosion rate and mass loss in carbon steel in high-concentration chloride mortars |
| 9:55–10:10 | **Alicia Montaño**<br>Selected Oral Speaker | Assessment of stainless steel corrosion in contact with acidic sludges encapsulated in alkali-activated slag cements |

| | | |
|---|---|---|
| 10:10–10:25 | **Meyssoune Meriem**<br>Selected Oral Speaker | Influence of Chloride and Sulfate Ions on the Electrochemical Behavior of Carbon Steel in Highly Alkaline Media |
| 10:25–10:40 | **Anthony John Betts**<br>Selected Oral Speaker | Review of the Prediction and Monitoring of the Corrosion of Reinforced Concrete Structures Using Electrochemical Methods |

## *Session 6. Corrosion and Integrity Management in Energy Infrastructure (Afternoon Session)*

***Time: 14:00 (CEST, Basel) | 08:00 (EDT, New York) | 20:00 (CST, Beijing)***

| Time in CET | Speaker | Title |
|---|---|---|
| 14:00–14:05 | **Prof. Dr. Frank Cheng**<br>Welcome from the Session Chair | |
| 14:05–14:40 | **Prof. Dr. Jing-Li Luo**<br>Keynote Speaker | Corrosion-Resistant and Conductive Coatings for Metal Bipolar Plates in Proton Exchange Membrane Fuel Cells |
| 14:40–15:15 | **Prof. Dr. Tom Depover**<br>Keynote Speaker | Assessment of hydrogen compatibility in pipeline steels: screening, susceptibility, and mitigation |
| 15:15–15:40 | **Prof. Damien Feron**<br>Invited Speaker | How to predict corrosion over millenniums? |
| 15:40–15:55 | **Yanan Pu**<br>Selected Oral Presenter | Comparative Study on SRB-Induced Corrosion of 90/10 Copper-Nickel Alloy Welded Joints: Anaerobic Bulk Immersion vs. Thin Liquid Film Environments |
| 15:55–16:10 | **Fei Xue**<br>Selected Oral Presenter | A laser-polished subsurface microstructural barrier mitigates hydrogen embrittlement in high-pressure hydrogen environments |
| 16:10–16:25 | **Maria Andrea Reyes Reyes**<br>Selected Oral Presenter | Fungal-Induced Degradation of Polymeric and Composite Materials in Energy Infrastructure |
| 16:25–16:40 | **Raúl Dávalos Monteiro**<br>Selected Oral Presenter | Corrosion Behavior of ASTM A36 Steel in Antarctic Marine and Glacier Waters: An Electrochemical and Gravimetric Study |
| 16:40–16:55 | **Alejandra Blanco**<br>Selected Oral Presenter | From Detection to Action: EMAT-Driven SCC Assessment |
| 16:55–17:10 | **Chandra Prakash**<br>Selected Oral Presenter | Electrochemical corrosion measurements in low-conductivity bio-oils: decoupling interfacial film memory from bulk electrolyte aging |
| 17:10–17:25 | **Emily Seto**<br>Selected Oral Presenter | Electrochemical Corrosion Assessment of Steels with Varying Chromium Content in NO2-containing Phase-Transition Environments in CCUS Infrastructure |
| 17:25–17:40 | **M Bakhtiar Azim**<br>Selected Oral Presenter | Decoding Stress Corrosion Cracking in Metallurgical Point-of-View: A Threat to the Structural Integrity of North American Pipeline Infrastructure for Reliable Energy Transportation and Supply in Critical Sectors |

## 1st July 2026 (Wednesday)

### *Session 5. Corrosion in Biomedical Implants (Morning Session)*

***Time: 09:00 (CEST, Basel) | 03:00 (EDT, New York) | 15:00 (CST, Beijing)***

| Time in CEST | Speaker | Title |
|---|---|---|
| 9:00–9:10 | **Conference Chair**<br>Welcome from the Conference Chair | |
| 9:10–9:15 | **Prof. Angeliki Lekatou**<br>Welcome from the Session Chair | |
| 9:15–9:40 | **Prof. Dr. Vasily Efremenko**<br>Invited Speaker | Corrosion and Tribocorrosion Behaviour of Wrought and LPBF Ti-6Al-4V Alloys for Biomedical Applications |
| 9:40–10:05 | **Prof. Simeon Agathopoulos**<br>Invited Speaker | Design and fabrication of metal-ceramic biomaterials |
| 10:05–10:20 | **Solomon Ansah**<br>Selected Oral Presenter | A comprehensive assessment of the effect of bovine serum albumin on the stress corrosion cracking and corrosion behaviour of Mg-Ca alloy |
| 10:20–10:35 | **Nina Kovac**<br>Selected Oral Presenter | Improving Corrosion Resistance of AZ31 Alloy using Zr/Si Sol–Gel Coating in Simulated Body Fluid |
| 10:35–10:50 | **Jean Geringer**<br>Selected Oral Presenter | Point Defect Model, PDM: Predicting metallic implant lifetime—what we did and what we will do! |
| 10:50–11:05 | **Zanele Phasha**<br>Selected Oral Presenter | Effect of Different Annealing Temperatures on the Phase Analysis, Microstructures and Corrosion Resistance of Binary Ti-Cu Alloys |

### *Session 1. Electrochemical Corrosion Mechanism at the Interface (part 1)*

***Time: 09:00 (CEST, Basel) | 03:00 (EDT, New York) | 15:00 (CST, Beijing)***

| Time in CEST | Speaker | Title |
|---|---|---|
| 11:05–11:10 | **Prof. Dr. David Bastidas**<br>Welcome from the Session Chair | |
| 11:10–11:45 | **Prof. Dr. Ramón Nóvoa Rodríguez**<br>Keynote Speaker | A contactless methodology for measuring the corrosion rate of steel in concrete |
| 11:45–12:20 | **Prof. Dr. Robert E. Melchers**<br>Keynote Speaker | Passivity, passivity breakdown and development of pitting corrosion |
| 12:20–12:35 | **Shuhao Li**<br>Selected Oral Presenter | Size-Dependent Structural Evolution of Fe(OH)3 Oligomers from Dimer to Decamer: A Quantum Mechanical Search toward Early Corrosion Products |
| 12:35–12:50 | **Dirk Engelberg**<br>Selected Oral Presenter | Correlative Assessment of Corrosion & Degradation Mechanisms using Electrochemical Screening Techniques |

### *Session 1. Electrochemical Corrosion Mechanism at the Interface (part 2)*

***Time: 14:00 (CEST, Basel) | 08:00 (EDT, New York) | 20:00 (CST, Beijing)***

| Time in CET | Speaker | Title |
|---|---|---|
| 14:00–14:35 | **Prof. Dr. Mirna Urquidi-Macdonald**<br>Keynote Speaker | The Importance of Understanding Metal Passivity |
| 14:35–15:10 | **Prof. Dr. Roger Newman**<br>Keynote Speaker | Pitting of stainless alloys - revisiting the critical pitting temperature |
| 15:10–15:35 | **Dr. Rebecca Filardo Schaller**<br>Invited Speaker | Localized Corrosion: In-situ Techniques to Investigate the Controlling Variables |
| 15:35–16:00 | **Dr. Xiaolei Guo**<br>Invited Speaker | Critical role of surface conditions on atomospheric corrosion and pit-to-crack transition in stainless steel 304H |
| 16:00–16:25 | **Dr. Dev Chidambaram**<br>Invited Speaker | Understanding Corrosion Behavior in Molten Salt Systems |

| | | |
|---|---|---|
| 16:25–16:50 | **Professor Raghu Srinivasan**<br>Invited Speaker | Integrating Time-of-Wetness and Electrochemical Methods to Predict Atmospheric Galvanic Corrosion of Aluminum Alloys |
| 16:50–17:05 | **Joseph S Moema**<br>Selected Oral Speaker | Electrochemical corrosion behaviour of brazed and unbrazed one-layer material AA4045/AA3003mod: Influence of soaking time |
| 17:05–17:20 | **Thomas Curtin**<br>Selected Oral Speaker | Challenges in Modeling Fatigue Cracking of a Pre-Corroded AA7075-T651 Dogbone Specimen with Galvanically Induced Damage at a Simulated Fastener Hole |
| 17:20–17:35 | **Sadegh Pour-Ali**<br>Selected Oral Speaker | Mo-Driven Transition in Passivation and Localized Corrosion of Fe–9Cr–xMo Alloys: From Enhanced Film Stability to Heterogeneity-Assisted Breakdown |

## 2st July 2026 (Thursday)

### *Session 5. Corrosion in Biomedical Implants (Morning Session)*

***Time: 09:00 (CEST, Basel) | 03:00 (EDT, New York) | 15:00 (CST, Beijing)***

| Time in CEST | Speaker | Title |
|---|---|---|
| 9:00–9:10 | **Conference Chair**<br>Welcome from the Conference Chair | |
| 9:10–9:15 | **Dr. Sviatlana Lamaka**<br>Welcome from the Session Chair | |
| 9:15–9:40 | **Prof. Dr. Di Mei**<br>Invited Speaker | The selection of corrosion inhibitors for Mg alloys via the evaluation of mechanical integrity |
| 9:40–10:05 | **Prof. Dr. Rob Lindsay**<br>Invited Speaker | In Silico Discovery: For Drugs to Corrosion Inhibitors |
| 10:05–10:30 | **Dr. Matic Poberznik**<br>Invited Speaker | From Molecular Models to Surfaces: First-Principles Insights into Inhibitor Adsorption on Oxidized Aluminum Surfaces |
| 10:30–10:45 | **Heshani Balasooriya**<br>Selected Oral Presenter | Computational Experiments for Designing High-Performance Oxadiazole Corrosion Inhibitors |
| 10:45–11:00 | **Elias De Ketelaere**<br>Selected Oral Presenter | Electrochemical insights on silicate-based corrosion inhibition for pipeline materials |
| 11:00–11:15 | **Alex Palma-Cando**<br>Selected Oral Presenter | Integrated Phytochemical and Electrochemical Screening of Sustainable Corrosion Inhibitors from Biomass and Agro-Industrial Waste for Admiralty Brass |

### *Flash Poster Session*

***Time: 09:00 (CEST, Basel) | 03:00 (EDT, New York) | 15:00 (CST, Beijing)***

| Time in CEST | Speaker | Title |
|---|---|---|
| 11:15–11:20 | **Yutao Tian**<br>Poster Presenter | Surface Treatments and Coatings for Corrosion Protection in Deep-Sea Marine Ranching Equipment |
| 11:20–11:25 | **Xinhui Jiang**<br>Poster Presenter | Mechanism of $SO_2$ Effects on the Formation, Evolution, and Corrosion Behavior of $CO_2$ Corrosion Product Films on Carbon Steel |
| 11:25–11:30 | **Yuanyuan Ji**<br>Poster Presenter | Oxide film formation and intergranular corrosion susceptibility of sensitized 5083 Al-Mg alloy: The role of tensile stress |
| 11:30–11:35 | **Reshma Patale**<br>Poster Presenter | Influence of Surface Treatment on Hydrogen Embrittlement of Commercial Vehicle Seat Slider Bracket |
| 11:35–11:40 | **Fatemeh Akhlaghi**<br>Poster Presenter | Investigation of Biodegradability of Wrought Mg-Ca-Mn Alloy as a Potential Material for Urological Applications |
| 11:40–11:45 | **Svetlana Boshnakova**<br>Poster Presenter | Pitting Corrosion Restoration Solution for Thick Pipe by Additive Manufacturing |
| 11:45–11:50 | **Chigozie EBUNUOHA**<br>Poster Presenter | Extending the Service Life of Ageing FPSO and SPM Calm Buoys Under Corrosion Effects: A Case Study on the Hull and Deck Plates |
| 11:50–11:55 | **Veronica Morudu**<br>Poster Presenter | Effect of Iron (Fe) on the Corrosion Performance of NiCr-based Alloys |
| 11:55–12:00 | **Yashwantraj Seechurn**<br>Poster Presenter | Atmospheric corrosivity in a bagasse/coal co-firing power plant influenced by a tropical marine climate |

### *Session 8: AI and ML Tools and Digital Twins for Corrosion Prediction (Afternoon Session)*

***Time: 14:00 (CEST, Basel) | 08:00 (EDT, New York) | 20:00 (CST, Beijing)***

| Time in CET | Speaker | Title |
|---|---|---|
| 14:00–14:05 | **Prof. Alankar Alankar &**<br>**Prof. Dr. Nick Birbilis**<br>Welcome from the Session Chairs | |

| | | |
|---|---|---|
| 14:05–14:30 | **Prof. Dr. Florin Bobaru**<br>Invited Speaker | Peridynamic models for corrosion damage: towards digital twins for corrosion prediction |
| 14:30–14:45 | **Shin Ohara**<br>Selected Oral Presenter | Evaluation of the applicability of dose–response functions incorporating time of wetness: Analysis of outdoor exposure test data for carbon steel and zinc across multiple countries |
| 14:45–15:00 | **Kazuma Shibano**<br>Selected Oral Presenter | Detection of Pitting Corrosion in Stainless Steel Sheet Pile Walls using Deep Learning |
| 15:00–15:15 | **Johnny MUHINDO BAHAVIRA**<br>Selected Oral Presenter | Machine learning-based prediction of carbonation-induced reinforcement corrosion initiation risk in reinforced concrete under Kinshasa climate conditions |

## *Session 4: Corrosion in New Materials (HEA, CCA, TWIP/TRIP, AM, PM)*

***Time: 14:00 (CEST, Basel) | 08:00 (EDT, New York) | 20:00 (CST, Beijing)***

| Time in CET | Speaker | Title |
|---|---|---|
| 15:15–15:20 | Prof. Dr. Homero Castaneda-Lopez<br>Welcome from the Session Chair | |
| 15:20–15:55 | **Prof. Dr. Rhys Jones**<br>Keynote Speaker | Boeing Space, Intelligence and Weapons Systems Laser Powder Bed Scalmalloy A Paradigm Shift That Overcomes Environmental Degradation in High Strength Aluminium Alloys |
| 15:55–16:20 | **Prof. Dr. Rajeev Kumar Gupta**<br>Invited Speaker | Corrosion of additively manufactured alloys: examples of using additive manufacturing in improving corrosion resistance |
| 16:20–16:35 | **Alireza Sohrabi**<br>Selected Oral Presenter | Investigating the Mechanical and Corrosion Properties of Ti 21S Produced via Laser Powder Directed Energy Deposition: A Viable Alternative to Ti-6Al-4V for Biomedical Implants |
| 16:35–16:50 | **Angel G Fernández**<br>Selected Oral Presenter | Evaluation of Al additions to high-entropy alloys as structural material for the next generation of CSP plants |
| 16:50–17:05 | **Adriana da Cunha Rocha**<br>Selected Oral Presenter | Oxidation behaviour of a CrCoNiAlTi multicomponent alloy |
| 17:05–17:10 | Conference Chair<br>Closing Remarks | |

| Poster List | | |
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| **sciforum-162152** | Yutao Tian, Zhengxun Zhou, Hongming Gu, Huaxian Feng, Pengji Li, Sixing Guo, Zehan Chen, Dapeng Zhang | Surface Treatments and Coatings for Corrosion Protection in Deep-Sea Marine Ranching Equipment |
| **sciforum-168495** | Svetlana Boshnakova | Pitting Corrosion Restoration Solution for Thick Pipe by Additive Manufacturing |
| **sciforum-168517** | Xinhui Jiang, Min Qin, Kexi Liao | Mechanism of $SO_2$ Effects on the Formation, Evolution, and Corrosion Behavior of $CO_2$ Corrosion Product Films on Carbon Steel |
| **sciforum-168539** | Yuanyuan Ji, Da-Hai Xia, Wenbin Hu, Bernard Tribollet | Oxide film formation and intergranular corrosion susceptibility of sensitized 5083 Al-Mg alloy: The role of tensile stress |
| **sciforum-168551** | Vielet Semakaleng Marutha, Marandela Mulaudzi, Maje Phasha | The use of DFT first principles and FactSage simulation methods to predict the phase stability of FCC Ni-Cr-Al alloys in an attempt to improve metal dusting resistance in the petrochemical industry |
| **sciforum-171348** | Barathkumar Krishnan | Failure Investigation of a Duplex Stainless Steel Flange: Role of Improper Heat Treatment and Sigma Phase Embrittlement |
| **sciforum-173378** | Fatemeh Akhlaghi, Nader Parvin, Ahmad Bahmani, Bahzad Nayebi | Investigation of Biodegradability of Wrought Mg-Ca-Mn Alloy as a Potential Material for Urological Applications |
| **sciforum-173551** | Yashwantraj Seechurn | Atmospheric corrosivity in a bagasse/coal co-firing power plant influenced by a tropical marine climate |
| **sciforum-176510** | Chigozie EBUNUOHA, Ebigenibo G. Saturday, Celestine E. Ebieto | Remaining Useful Life Estimation of SPM and FPSO Mooring Chains Under Corrosion Effects |
| **sciforum-176514** | Chigozie EBUNUOHA, Ebigenibo G. Saturday, Celestine E. Ebieto | Extending the Service Life of Ageing FPSO and SPM Calm Buoys Under Corrosion Effects: A Case Study on the Hull and Deck Plates |
| **sciforum-177871** | Shirish Bali, Reshma Patale, Srikanth T S | Influence of Surface Treatment on Hydrogen Embrittlement of Commercial Vehicle Seat Slider Bracket |
| **sciforum-180609** | Weiguo Li | The influence of surface scratch roughness on the hydrogen embrittlement sensitivity of X80 pipeline steel |
| **sciforum-181086** | Yuto Takahashi, Kazuma Shibano, Taiki Hagiwara, Tetsuya Suzuki | Non-contact Evaluation of Coating System Re-deterioration in Steel Sheet Pile Canal |
| **sciforum-181183** | Heshani Balasooriya, Shuhao Li, Chunqing Li, Feng Wang | Role of Surface Vacancies in Chloride-Induced Corrosion of Fe(100) |
| **sciforum-181258** | Merouane KHODJA, Sakina Radia DIDOUCHE, Azzeddine NACER, Hocine MOULAI | Experimental Assessment of Dielectric Stability in Transformer Oil Using Partial Discharge Energy Signatures |

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| **sciforum-150984** | Lyudmila Ivanivna Nyrkova, Goncharenko Valerianivna Larysa, Svetlana Oleksiivna Osadchuk, Yulia Oleksiivna Kharchenko | Susceptibility To Stress-Corrosion Cracking Of Long-Operated Gas Pipeline Steel In A Model Soil Electrolyte |
| **sciforum-180539** | Johnny MUHINDO BAHAVIRA, Papy KABADI LELO ODIMBA, Aristote Zenga Anselme, Michael Paluku Lukumbi, Junior Lukoo Mitsindo | Machine learning-based prediction of carbonation-induced reinforcement corrosion initiation risk in reinforced concrete under Kinshasa climate conditions |
| **sciforum-181846** | Veronica Morudu, Nthabiseng Maledi, Marandela Mulaudzi, Maje Phasha | Effect of Iron (Fe) on the Corrosion Performance of NiCr-based Alloys |
| **sciforum-173601** | Raja Naveen Varma Kucharlapati, Susanta Sinha Roy | Electrochemical Impedance Spectroscopy Study of Corrosion Resistance of RF-Sputtered Titania Thin-Film-Coated SS316 in 3.5 wt.% NaCl |

# Session 1. Electrochemical Corrosion Mechanism at the Interface (Localized, Crevice, Advanced Characterization Techniques, EAC, Nanoscale)

# sciforum-173225: Challenges in Modeling Fatigue Cracking of a Pre-Corroded AA7075-T651 Dogbone Specimen with Galvanically Induced Damage at a Simulated Fastener Hole

**Thomas Curtin [1], Sharon Mellings [2], Kristen Williams [3], Ahmad Ivan Karayan [3], Joe Indeck [3]**

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[3] Boeing Technology Innovation, Huntsville, AL 35824, USA

This work focuses on using representative corrosion damage morphology, determined from fractography, to predict crack propagation behavior in a test article under fatigue load. A dogbone specimen (AA7075-T651) with a simulated fastener hole was pre-corroded using atmospheric corrosion conditions (RH = 80%, salt load = 1000 mg/m$^2$, T = 25$^o$ C). A CFRP insert was placed in a through hole on the side surface of the dogbone to represent a fastener system and to promote local corrosion through galvanic coupling. A thin non-conductive separator was placed between the CFRP insert and the AA7075-T651 through hole to prevent physical contact between those two materials. The specimen was salt dosed and placed in an environmental chamber with controlled relative humidity and temperature. A zero-resistance ammeter test of the CFRP/AA7075-T651 couple was performed for 10 days to induce galvanic corrosion damage on the surface surrounding the through hole mouth. Following pre-corrosion, the dogbone specimen was tested under constant amplitude fatigue load ($S_{max}$ = 25.11 ksi, R = 0.89) in laboratory air; the total fatigue life measured experimentally was 230,135 cycles. Following fatigue testing the failed specimen was inspected for corrosion-related crack initiation sites and final crack shape using SEM imaging. A computational fracture mechanics model, based on the boundary integral method, was developed to simulate the fatigue test. Fractographic imaging was used to size and locate initial flaws in the through hole. To approximate the anticipated short-to-long crack transition, the Hartman–Schijve equation was fitted to a crack growth kinetic data set and used to drive the simulation model. A range of model inputs were selected to understand the sensitivity of fatigue life predictions to the fracture mechanics model inputs used to represent the complex corrosion damage morphology. The computational model produced results that were in reasonable agreement with the experimental test.

# sciforum-168900: Correlative Assessment of Corrosion & Degradation Mechanisms using Electrochemical Screening Techniques

**Dirk Engelberg**

Corrosion@Manchester, Department of Materials, The University of Manchester, UK

This presentation will provide new insights and ideas to address the relationship among environmental exposure parameters, the presence of applied and residual stress, and microstructure/metallurgy performance. Electrochemical screening and sensing techniques have been explored to assess local corrosion reactions, selective dissolution and passivation behavior, and to observe the nucleation of environmentally assisted cracking (EAC). Typical examples and innovative approaches to advance our mechanistic understanding of localized corrosion and EAC are discussed, with the aim of better understanding mechanistic behavior and extending component lifetime. Techniques for measuring corrosion kinetic behavior, passive film composition, and crack-nucleation propensity are introduced, and the application of electrochemical techniques is elaborated. A range of new ideas is presented, including the application of electrochemically controlled micro-/nano-indentation tests, in situ confocal microscopy of hydrogen embrittlement (HE), and 2D/3D/4D corrosion and crack growth measurements using advanced imaging methods. These tests are then combined with chemical fingerprinting of corrosion products using (spectral) imaging approaches. The development of corrosion chemistry is observed over time, yielding information about local passivation behavior under redox conditions. We present work on aluminum alloys, stainless steels, and Ni-base alloys, addressing material behavior for marine exposure, petrochemical applications, and nuclear/radwaste exposure regimes. Results from different characterization techniques will be compared and correlated to their electrochemical responses.

# sciforum-158618: Critical role of surface conditions on atmospheric corrosion and pit-to-crack transition in stainless steel 304H

**Xiaolei Guo, Hailong Dai, Casey Niebuhr**

Colorado School of Mines

During dry storage of spent nuclear fuel, the stainless steel (SS) canisters used for containment are cooled by ambient air that often carries fine salt aerosols. These airborne salts can accumulate on the canister surface and, in the presence of humidity, deliquesce to form concentrated chloride brines that promote localized corrosion and ultimately stress corrosion cracking. The present work investigates the initiation of pitting corrosion and the subsequent pit-to-crack transition in SS304H under simulated canister-relevant environments. Three surface preparation methods, including hand grinding, machine grinding, and milling, were used to create specimens with varying degrees of surface deformation and residual stress. A MgCl2-rich brine was employed to reproduce the chemistry expected after deliquescence at approximately 40 % relative humidity. To generate a range of pit morphologies, specimens were exposed to controlled atmospheric corrosion under constant relative humidity and temperature. The results showed that machine milling introduced a substantial near-surface deformation and tensile residual stress, leading to the formation of the most severe pitting corrosion and long cracks. Additionally, dealloying was found in machine-ground specimens exposed to the simulated brine after only two days. The results highlight the importance of residual stress on localized corrosion and the pit-to-crack transition in atmospheric conditions.

# sciforum-168681: Electrochemical corrosion behaviour of brazed and unbrazed one-layer material AA4045/AA3003mod: Influence of soaking time.

**Dr Joseph S Moema [1,2], Charles W Siyasiya [2], Veronica K Morudu [1], Nomsombuluko Hadebe [3], Maje J Phasha [1]**

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Aluminium alloys have become the material of choice for automotive heat exchangers due to their favourable mechanical properties and corrosion resistance. While the impact of homogenization temperature and duration on AA3xxx alloys has been studied, the specific effect of preheating holding time on clad AA3003mod alloys remains underexplored. This study investigates how isothermal soaking time influences the microstructure and corrosion resistance of AA3003mod alloy clad with AA4045, a configuration used in automotive brazing sheets. To replicate industrial production, hot-rolled and homogenised slabs underwent thermo-mechanical processing. Sandwich samples of AA4045/AA3003mod were preheated at 505 °C for 20, 30, 35, 40, 38 and 45 hours. Corrosion resistance was assessed using potentiodynamic through open-circuit potential (OCP) measurements and potentiostatic polarisation techniques in a 3.5% NaCl solution, with pitting quantitatively analysed via an Olympus Microscope equipped with a 3D imaging software and Scanning Electron Microscopy (SEM). The corrosion rates for all brazed samples exceeded the generally accepted standard of 0.1 mm/y. Pitting severity and current density peaked between 30 and 45 hours of homogenization, indicating reduced nobility. In contrast, samples homogenised for 20 hours exhibited minimal pitting, the shallowest pits, the most noble open-circuit potential, and the lowest current density, demonstrating that extended homogenization significantly deteriorates corrosion resistance of the roll bonded AA4045/AA3003mod sheets.

# sciforum-173362: Extraction of Kinetic Parameters in the Point Defect Model through Coupled Transient Current Response and Electrochemical Impedance Spectroscopy

**Dihao Chen** [1], **Jing Liu** [1], **Chaofang Dong** [2]

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[2] Institute for Advanced Materials and Technology, University of Science and Technology Beijing, Beijing 100083, China

Understanding the growth kinetics of passive films is crucial for controlling corrosion resistance. However, the mechanistic origin of the commonly observed current transients remains unclear, and uniquely determining the interfacial kinetic parameters remains challenging. In this presentation, the transient growth behavior of passive films on Fe, Ti, Ni, and Cu was investigated using potentiostatic current density-time (*I*-*t*) analysis combined with Mott–Schottky measurements. Within the framework of the point defect model (PDM), a systematic methodology was established to interpret *I*-*t* curves. A two-stage double-logarithmic relationship in log *I*–log *t* plots is attributed to film growth governed by oxygen vacancies coupled with metal cation interstitials or vacancies, whereas a single-stage behavior indicates control by a single defect type. The slope of the log *I*–log *t* plot is determined by the ratio of interfacial transfer coefficients, with a more negative slope corresponding to the formation of a denser passive film with fewer defects. Importantly, integrating *I*-*t* analysis with electrochemical impedance spectroscopy (EIS) enables quantitative determination of the kinetic parameters of interfacial defect reactions in the PDM. While *I*-*t* transients constrain transport and reaction kinetics during early-stage growth, EIS provides complementary information on interfacial reaction resistances and capacitances under steady-state conditions. Their combined application offers a more reliable and internally consistent strategy for extracting transfer coefficients and rate constants, thereby strengthening parameter identification within the PDM framework.

# sciforum-158632: Integrating Time-of-Wetness and Electrochemical Methods to Predict Atmospheric Galvanic Corrosion of Aluminum Alloys

**Raghu Srinivasan**

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Atmospheric galvanic corrosion of aluminum alloys continues to challenge accurate prediction and mitigation, particularly in mixed-material systems used in aerospace and marine environments. This includes systems exposed to dynamic atmospheric conditions where wet–dry cycling, chloride deposition, and microstructural heterogeneity govern degradation processes. Aluminum alloys, valued for their strength-to-weight ratio and passivity, are particularly susceptible to localized and galvanic attack when combined with dissimilar materials in aerospace, marine, and energy infrastructure.

Conventional salt-spray or cyclic corrosion tests fail to replicate the complex wet–dry cycling and localized electrochemical interactions that govern long-term atmospheric degradation. This study explores how to integrate a hybrid framework combining accelerated laboratory electrochemical techniques with time-of-wetness (TOW) to better predict the atmospheric galvanic behavior of 6061-T6 aluminum (UNS A96061) coupled with stainless steel (UNS S30400), copper (UNS C11000), and carbon-fiber reinforced polymer composites (CFR PMC).

Zero-resistance ammeter (ZRA) experiments were performed in a controlled-humidity chamber and a cyclic-corrosion test chamber under varying chloride concentrations to simulate different atmospheric exposures. The galvanic current data were correlated with modified Faraday-based equations incorporating measured TOW to estimate corrosion rates in g $m^{-2}$ $day^{-1}$. The aluminum–copper couple exhibited the highest current densities and corrosion rates (up to 12 g $m^{-2}$ $day^{-1}$) under high-chloride conditions, while aluminum–CFR PMC and aluminum–stainless-steel couples showed comparable but lower rates. The integrated approach successfully bridged the gap between accelerated tests and real atmospheric behavior by quantifying the effects of wet/dry cycles on galvanic kinetics.

The findings highlight the potential of TOW-based electrochemical modeling as a predictive tool for assessing material compatibility and optimizing design in dissimilar-metal assemblies. Future work includes more cyclic corrosion chamber testing and outdoor validation at various exposure sites to refine the correlation between laboratory and field data.

# sciforum-173429: Mo-Driven Transition in Passivation and Localized Corrosion of Fe–9Cr–xMo Alloys: From Enhanced Film Stability to Heterogeneity-Assisted Breakdown

**Sadegh Pour-Ali, Jing Liu**

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Ferritic/martensitic 9Cr heat-resistant steels are extensively used in high-temperature steam power systems due to their balanced creep strength and oxidation resistance. However, during start-up, shut-down, hydrotesting, and wet layup conditions, these alloys experience aqueous exposure where electrochemical corrosion and localized attack may compromise structural integrity. Although molybdenum (Mo) is a key alloying element in 9Cr steel families, its independent role in governing passive film stability and breakdown remains unclear due to strong compositional coupling in commercial grades. This study aims to isolate and quantify the intrinsic effect of Mo on passivation and localized corrosion behavior using a systematic model alloy approach. A Fe–9Cr–xMo (x = 0–18 wt.%) model alloy series was developed to maintain a constant chromium backbone while varying Mo as the primary design variable. Electrochemical behavior was evaluated in chloride-containing aqueous environments using potentiodynamic polarization, cyclic polarization, repassivation potential analysis, and critical pitting temperature measurements. Microstructural characterization was performed to correlate electrochemical responses with compositional heterogeneity and secondary phase formation. Mo content modifies passive behavior in a non-linear manner. Intermediate Mo levels enhance passive film stability, increase breakdown and repassivation potentials, and elevate critical pitting temperature, indicating improved localized corrosion resistance. In contrast, higher Mo contents promote microstructural heterogeneity and metastable pitting activity, reducing repassivation efficiency and narrowing the passive stability window. These results suggest a composition-dependent transition from Mo-enhanced passivation to heterogeneity-assisted breakdown. This work establishes a quantitative composition–passivation–breakdown relationship for Fe–9Cr–xMo alloys and identifies a mechanistic threshold in Mo content controlling localized corrosion resistance. The findings provide fundamental insight for optimizing 9Cr-based steels subjected to combined steam and aqueous exposure in energy infrastructure applications.

# sciforum-124557: Numerical Simulation of Aluminum Pitting Corrosion: Influence of Electrolyte Conductivity and Nitrate/Sulfate Ions

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This study investigates the numerical simulation of aluminum pitting corrosion in a 1 M NaCl solution using a two-dimensional model based on secondary current distribution with a deforming geometry, implemented in COMSOL Multiphysics. The model enables the analysis of the influence of electrolyte conductivity, as well as the effect of nitrate ($NO_3^-$) and sulfate ($SO_4^{2-}$) ions, added at concentrations of 0.01, 0.02 and 0.03 M, on pit growth and morphology.

The simulations show that increasing electrolyte conductivity enhances ionic migration, leading to higher anodic current density and an increased concentration of dissolved species, particularly near the pit mouth. The difference observed between the pit mouth and the pit bottom is attributed to the ohmic drop within the cavity, which limits the anodic current at the pit bottom and promotes preferential dissolution at the pit entrance, resulting in lateral pit widening.

Furthermore, the addition of nitrate ($NO_3^-$) and sulfate ($SO_4^{2-}$) ions increases the corrosion current density, indicating an acceleration of pit propagation. A consistent increase in corrosion current density with increasing ion concentration (0.01-0.03 M) is observed, highlighting the role of ionic strength in enhancing anodic dissolution and controlling pit propagation kinetics. Sulfate ions exhibit a stronger effect on corrosion activity than nitrate ions. Morphological analysis suggests that $SO_4^{2-}$ ions mainly promote lateral pit propagation, whereas $NO_3^-$ ions favor preferential depth growth. These behaviors are associated with differences in ionic mobility and dissolution processes occurring within the pit environment.

Overall, the results highlight that the kinetics and morphological evolution of aluminum pitting corrosion are strongly governed by ohmic drop, electrolyte conductivity, ionic strength and the nature and mobility of the ionic species present in solution.

# sciforum-168534: Passivation and Material Science: A tribute to Prof. Digby D. Macdonald...

**Normand Bernard**

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Passivation is a key factor in the durability of materials. It presents an even more crucial challenge when we are faced with the challenges of environmental and climate transitions. These challenges require control and mastery of resources, sustainability and material manufacturing processes. In this context, the work of Prof. Digby D. Macdonald is both pioneering and important.

Today, it has inspired a great number of studies, and, when they are discussed, Digby D. Macdonald's research inspires many developments, attested to by the emergence of numerous models based on the renowned Point Defect Model.

Of course, this is not to reduce Prof. Digby D. Macdonald's work to passivation alone, but this presentation attempts to provide a brief overview of how his work, and that of his closest collaborator, Prof. Mirna Macdonald, has inspired me in my career as a corrosion specialist in particular and a materials scientist in general.

Beyond the mechanisms of passive film formation, the presentation will mainly focus on illustrating how the theme of passivation can enrich our knowledge of the role of additives on the one hand, and the conceptualisation of anti-corrosion solutions through the optimisation or definition of new materials, on the other hand.

The first topic will focus on the study of the effect of nitrogen on passivation and how the work carried out with Digby D. and Mirna Macdonald has led to an understanding of the so-called nitrogen blocking effect in the transport of passive films. The second example will focus on the strategy developed to develop new materials for the deployment of fuel cells for electromobility based on passive film functionalising. Finally, I will illustrate the various links between passivation and the multifunctionality of materials, based on recent work on tribocorrosion under irradiation.

# sciforum-181183: Role of Surface Vacancies in Chloride-Induced Corrosion of Fe(100)

**Heshani Balasooriya [1], Shuhao Li [1], Chunqing Li [2], Feng Wang [1]**

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Steel corrosion presents significant economic, environmental, and safety challenges, particularly in chloride-rich environments. At the atomic level, corrosion arises from competition between protective oxygen adsorption and chloride-driven depassivation. Although these processes are well characterised on ideal Fe surfaces, the role of surface defects in modulating this balance remains poorly understood. In this study, spin-polarised density functional theory (DFT) calculations were used to systematically examine defect-controlled corrosion reactivity on the Fe(100) surface. Three surface models are considered: pristine Fe(100) (Fe(100)-P), adatom-modified Fe(100) (Fe(100)-A), and vacancy-defective Fe(100) (Fe(100)-V). Adsorption energies and electronic structures are computed to quantify defect-driven changes in O- and Cl-binding at the most stable sites. Oxygen adsorption is found to be strongest on the pristine surface, consistent with effective passivation (Fe(100)-P > Fe(100)-A > Fe(100)-V). Vacancy defects markedly weaken O binding, suppressing protective oxide film formation, while adatoms have only a minor influence. In contrast, Cl adsorption is significantly enhanced at vacancy sites (Fe(100)-V > Fe(100)-P > Fe(100)-A), identifying vacancies as preferential Cl-accumulation sites that accelerate passive-film breakdown. These findings establish vacancy defects as dual corrosion promoters that simultaneously hinder passivation and enhance Cl-induced depassivation. Detailed atomistic and mechanistic analysis of these defect effects will be presented, offering practical guidance for defect-engineered alloy design and advanced surface treatment strategies to achieve superior corrosion resistance.

# sciforum-181322: Size-Dependent Structural Evolution of Fe(OH)3 Oligomers from Dimer to Decamer: A Quantum Mechanical Search toward Early Corrosion Products

**Shuhao Li [1], Vladislav Vasilye [2], Chunqing Li [3], Heshani Balasooriya [1], Feng Wang [1]**

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Early ferric hydroxide species are important precursors in the formation of corrosion products, yet their atomistic evolution from small molecular aggregates to crystal-like motifs remains poorly understood. In this work, we adapt a robust quantum mechanical conformer-search method developed by Wang and Vasilyev to Fe(OH)3 oligomers and systematically investigate the most stable structures from the dimer to the decamer. For each oligomer size, diverse candidate geometries were generated and optimized, followed by energy- and geometry-based screening to identify the lowest-energy structures and representative low-energy isomers. The calculations reveal pronounced size-dependent stabilization and structural reorganization during oligomer growth, together with clear changes in Fe coordination environments, Fe–O connectivity, and electronic properties. The evolution of hydroxyl-bridged frameworks and Fe–O polyhedral connectivity provides insight into how local bonding patterns develop with increasing oligomer size. In addition, the relative stabilities of the low-energy structures indicate that specific oligomer sizes may act as favorable intermediates during the early-stage nucleation of corrosion products. These results suggest that the aggregation of Fe(OH)3 does not proceed as a simple monotonic growth process, but instead involves preferred structural motifs at specific oligomer sizes. Comparisons with representative crystalline corrosion products further clarify how early Fe(OH)3 oligomers evolve toward bulk corrosion phases. This study provides a molecular-level picture of the initial stages of corrosion-product formation and offers a computational route to bridge molecular corrosion precursors with experimentally observed crystalline products.

# Session 2. Corrosion of Steel in Concrete

# sciforum-168468: A contactless methodology for measuring the corrosion rate of steel in concrete

**Belén Díaz, Antonio Diéguez, X. Ramón Nóvoa, Carmen Pérez**

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Most reinforced concrete structures currently in service are approaching the end of their design life. To avoid premature or unexpected failures, periodic inspection is essential for planning maintenance and repair actions when required. Predicting the remaining service life relies on data obtained from non-destructive testing (NDT). Among NDT techniques, electrochemical methods are the only ones capable of providing information on both the initiation of rebar corrosion and the estimation of corrosion rates.

Electrochemical methods require electronic equipment to control two, three, or four electrodes, as well as an electrical connection to the rebar under investigation in order to determine key parameters such as corrosion potential, corrosion rate (via polarisation resistance (Rp), Tafel scans, or galvanostatic pulse techniques), and concrete resistivity.

As a result, electrochemical measurements are labour-intensive and time-consuming, significantly limiting their applicability in field conditions. To address this limitation, our group is developing approaches to reduce measurement time while maintaining the reliability of the extracted information. This contribution reviews the recent literature on this subject and presents new results on the use of impedance spectroscopy in the high-frequency domain, demonstrating that relevant parameters, such as concrete resistivity and interfacial resistance, can be measured with the same experimental arrangement without electrical contact with the rebar.

# sciforum-167214: Assessment of stainless steel corrosion in contact with acidic sludges encapsulated in alkali-activated slag cements

**Alicia Pachón Montaño, María Criado Sanz**

Eduardo Torroja Institute of Corrosion Science. IETcc-CSIC, Madrid, Spain

Acidic decontamination sludges are currently unsuitable for final disposal due to their low pH and high concentrations of organic and complexing species, which hinder their direct stabilization and long-term management. In this work, an acidic liquid waste is immobilized using two types of alkali-activated slag binders, namely BFS-C and BFS-S, and the performance of these systems is compared with that of a reference Portland cement binder (R). In parallel, three stainless steel grades are evaluated as candidate materials for waste-conditioning drums intended for the containment of the immobilized waste. Electrochemical corrosion parameters are determined in order to assess the corrosion behaviour of the metallic materials when exposed to the different binder matrices. The results indicate that the duplex stainless steels 1.4482 and 1.4462, together with the austenitic stainless steel 1.4404, exhibit a moderate apparent tendency to corrode in the alkali-activated slag environment. However, surface examinations show that sulfide phases inherently present in the slag significantly influence the electrochemical response of the system. This effect leads to an overestimation of the actual corrosion activity derived from electrochemical measurements. Once this interference is taken into account, the results demonstrate that all three stainless steel grades are compatible with alkali-activated slag matrices and can be considered suitable materials for the confinement and conditioning of acidic liquid wastes.

# sciforum-168635: Characterizing mechanisms controlling pit growth of steel in concrete

**Christopher L. Alexander [1], Prakirti Singh [2]**

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Chloride-induced corrosion damage of steel in concrete typically initiates as localized pitting, which may either repassivate or continue to grow and evolve into more widespread forms of damage. However, models developed to forecast corrosion damage generally neglect the early stages of pitting corrosion. This omission stems in part from the assumption that traditional carbon steel reinforcement rapidly transitions to more general corrosion, as well as from the limited understanding of the fundamental mechanisms governing pitting corrosion in concrete. Most durability forecasting models therefore rely on a chloride threshold to distinguish between the period before and after corrosion initiation, implicitly assuming that exceeding a critical chloride content leads to widespread corrosion activation. In contrast, this paper explores an alternative framework grounded in established concepts of pit stability that are commonly applied to immersed and atmospheric corrosion systems.

This work seeks to elucidate the mechanisms controlling pit growth of steel in concrete through a combination of experimental methods and physics-based computational modeling, with the goal of identifying conditions under which repassivation may occur. Artificial pit experiments are employed to investigate the influence of concrete configuration on pit stability and repassivation behavior. The steel–concrete interface is highly complex and heterogeneous, and two key concrete properties are expected to play dominant roles in pitting corrosion: its ability to act as a diffusion barrier and its capacity to buffer pH. The former is anticipated to promote stable pit growth, whereas the latter is expected to favor repassivation.

# sciforum-176846: Corrosion rate and mass loss in carbon steel in high-concentration chloride mortars

**Siaw Foon Lee**

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Concrete production requires the use of fresh water to achieve better hydration, strength and durability, with an estimated consumption of around 1.7 % of the world's freshwater withdrawals. Although this percentage is small, concrete construction is mainly concentrated in urban areas, and this leads to regional freshwater scarcity because wastewater purification is costly. Thus, it is essential to explore other alternatives, such as using industrial waste brine, to solve the freshwater-scarcity problem.

This work investigated four different mortar mixtures, which were ordinary Portland cement (CemI), CemI with 8 wt% fly ash, CemI with 8 wt% silica fume and Portland cement type III (CemIII) with slag, mixed with 2.56 M NaCl synthetic-brine water at a water-to-binder ratio of 0.55. For each, a mixture without chloride was also made for comparison. Fresh properties and hardened properties were measured. The amount of chloride in hardened mortars was determined. The corrosion behaviors of three embedded carbon steels were monitored using the linear polarization resistance measurement.

Results showed that mortars containing chloride had a higher slump flow and higher air content than mortars without chloride. The presence of chloride in mortars had a tendency to reduce bending and compressive strength and increase porosity, except in CemIII with slag, which showed similar bending and compressive strength as well as porosity regardless of the presence of chloride. Mortars with silica fume and slag showed a higher chloride-binding capacity, reducing the amount of free chloride ions available to initiate corrosion in embedded carbon steels. Among all the mixtures, CemIII with slag showed a lower mass loss and corrosion rate of embedded carbon steel compared to CemI, even with the presence of chloride in the mortar.

This study supports the feasibility of using waste brine as a mixing liquidtogether with pozzolanic materials for producing sustainable mortar and reducing steel corrosion.

# sciforum-169466: Influence of Chloride and Sulfate Ions on the Electrochemical Behavior of Carbon Steel in Highly Alkaline Media

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This work explores the electrochemical behavior of carbon steel in highly alkaline solutions representative of concrete pore environments. The alkaline medium was prepared using NaOH, KOH, and $Ca(OH)_2$ to ensure conditions favorable to steel passivation. Chloride and sulfate ions were then added at different concentrations in order to study their individual and combined effects on corrosion behavior.

Electrochemical tests were carried out using open circuit potential (OCP), electrochemical impedance spectroscopy (EIS), and potentiodynamic polarization measurements at several immersion times. In solutions with no chloride or low chloride content, the steel showed stable passive behavior. This was reflected by relatively steady OCP values, high impedance levels, large phase angles, and low corrosion current densities, all indicating the presence of a protective passive film in the alkaline environment. When the chloride concentration was increased, this passive state became less stable. A clear decrease in impedance and polarization resistance was observed, together with higher corrosion current densities, suggesting degradation of the passive film and the onset of localized corrosion.

Compared to chlorides, sulfate ions had a milder effect on corrosion but still influenced the electrochemical response by modifying the solution chemistry and the characteristics of the passive layer. In media containing both chloride and sulfate ions, the corrosion behavior was found to depend on their relative concentrations and the exposure time. In some cases, competitive effects were observed, while in others, the combined influence of the two ions affected the stability of the passive film and the overall corrosion kinetics.

Overall, the results highlight the key role played by aggressive anions in controlling the corrosion behavior of carbon steel in highly alkaline media. This study provides useful insight into corrosion processes in concrete-related environments and underlines the importance of ion composition when assessing the durability of steel in alkaline pore solutions.

# Session 3. Surface Treatments and Coatings for Corrosion Protection

# sciforum-168605: Investigation of Binary and Ternary Ni-Based Alloys for High-Temperature Petrochemical Coating Applications

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This study is about the investigation of metal dusting (MD) on the alloys developed for coating in the petrochemical environments. Metal dusting is a corrosion phenomenon, which occurs in different materials, e.g., nickel-based alloys, resulting in material attack at high temperatures (350-800°C), when the carbon activity is greater than one ($a_C$>1). Alloys containing higher chromium contents can form a protective chromium oxide ($Cr_2O_3$) layer to retard MD. Protective oxide layers on the alloys form protection throughout the MD reaction period. Characterisations were undertaken on Ni-Cr and Ni-Cr-X (X = Al, Nb and Ti) alloys under heat-treated environments. Alloy compositions previously predicted using first-principle calculations were experimentally produced by a vacuum arc melting process. Before MD exposure, the alloys were annealed at 1100°C in the muffle furnace, and then water-quenched (WQ) and furnace-cooled (FC). Manufactured materials were investigated by optical microscopy (OM), scanning electron microscopy (SEM), and X-ray diffraction (XRD). The binary Ni-Cr and ternary Ni-Cr-X (Al, Nb and Ti) alloys were successfully produced using a vacuum arc melting technique. There manufactured alloys had scale layers on the surface after heat treatment. The alloys after etching showed austenitic microstructures. Cross-section SEM-EDS analysis showed that the alloys had developed chromium- and aluminium-oxide ($Cr_2O_3$ and $Al_2O_3$) layers on the surface after heat treatment. XRD revealed a complete austenite phase in all the ternary alloys. Metal dusting exposures and characterisation will be undertaken in further studies.

# sciforum-168495: Pitting Corrosion Restoration Solution for Thick Pipe by Additive Manufacturing

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**Introduction:** Recent advancements in the Directed Energy Deposition Wire Arc (DED-Arc) method for Additive Manufacturing have made it possible to restore damaged surfaces of pipes. Main focus is on pitting corrosion defect elimination because they are extremely detrimental when affecting large areas and may lead to safe operation impairment and subsequent decommissioning.

**Method:** A pipe made of 14MoV6-3 (1.7715 according to EN 10027) material sustained pitting and was heavily corroded. For the DED-Arc, filler wire was selected with a minimum molybdenum content (Ni-Alloy 625), which is very resistant to generalized aqueous acidic corrosion, pitting and stress corrosion cracking (SCC) in chloride-containing environments. No post-weld heat treatment (PWHT) was allowed in order not to corrupt the pipe outer geometry. Extracted samples were tested with microhardness measurement: bond strength, microcracking detection, porosity, interface zones assessment as well as microstructural analysis. After the application, visual testing (VT) for the surface quality was performed followed by ultrasonic testing (UT) as a non-destructive evaluation of the restored areas with checking for disbonding and internal imperfections.

**Results:** The DED-Arc method allows the restoration to be performed with 50 % overlapping of each successive pass and performing temper beat technique thus eliminating the need for PWHT. Strictly controlled parameters provide low dilution between material base and overlay with strong metallurgical bonding. The process has 0.4 to 0.7 KJ/mm heat input, no defects and the restored surface pass UT and VT. Pitting holes have been filled in. The deposition rate achieved is 5 kg/h. The corrosion behavior of the obtained cladded pipe proves satisfactory.

**Conclusion:** Successful restoration of corroded pipe has been performed by DED-Arc with improved rates of metal deposition and high quality which allow cost saving and extended equipment life.

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# sciforum-181950: Research Progress on LDHs@MXene Self-healing Composite Coatings

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MXenes are highly promising materials for self-healing coatings on Mg alloys. The high aspect ratio of MXenes material ensures its excellent physical barrier performance, prolongs the invasion path of corrosive ions, and gives it excellent corrosion resistance. In our various studies, Y-modified MXenes/MgAl LDHs composite coatings were successfully grown in situ on AZ31 magnesium alloy by the hydrothermal method. Rare earth ions Y increase the compactness of the corrosion product film, and the composite coating shows a very low corrosion current density of $9.12\times10^{-9}$ A·cm$^{-2}$. MXenes are good carriers of corrosion inhibitors due to their high specific surface area. 4-aminophenol@MXenes are prepared and introduced onto MgAlLa LDHs via a low-temperature water bath method. The scratched composite P/MgAlLa LDHs-M@A coating exhibits approximate $|Z|_{0.01\ Hz}$ with unscratched samples even after 12 h corrosion. Outer $(PEI/MXene)_n$-based layers were assembled on the surface of MgAl-$V_2O_7^{4-}$ LDHs film via the layer-by-layer (LbL) approach to further explore its physical barrier-blocking effect and protection mechanism for corrosion inhibition. In another study, electrophoretic deposition technology was further utilized to incorporate disordered MXenes onto the 2,5-Pyridinedicarboxylic acid (2, 5-PDCA)-modified ZnAl-LDHs coating. MXenes uniformly coated the 2,5 PDCA-LDH film, forming a protective barrier against corrosive species while simultaneously establishing a lubricating layer. Additionally, MXenes are applied as nanofiller to enhance the performance of epoxy resin (EP) coating, where the MXenes are modified with in situ grown ZnAl LDHs. The synergistic physical barrier effect of LDHs and MXenes effectively enhance the corrosion and wear resistance of EP coating.

# sciforum-162152: Surface Treatments and Coatings for Corrosion Protection in Deep-Sea Marine Ranching Equipment

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With the intensification of coastal water pollution and the increasing pressure on nearshore resources, marine aquaculture is gradually shifting toward offshore and deep-sea environments. Deep-sea aquaculture facilities are required to operate for extended periods under complex marine conditions, including high salinity, fluctuating dissolved oxygen levels, and severe biofouling. Therefore, the development of effective structural corrosion protection technologies for deep and far-sea aquaculture equipment is of critical importance. Among these technologies, surface treatment and protective coating systems play a pivotal role in mitigating and delaying corrosion-related degradation at material surfaces and interfaces, which govern most corrosion phenomena. Studies have shown that corrosion mechanisms and rates vary significantly with water depth and environmental conditions. In deep-water zones, reduced dissolved oxygen concentrations may inhibit oxygen-dependent electrochemical corrosion processes, while simultaneously promoting sulfide-induced corrosion. Under anaerobic conditions, the activity of microorganisms, such as sulfate-reducing bacteria, is enhanced, posing a serious threat to coating integrity and interfacial stability. In contrast, nearshore environments are more susceptible to photochemical reactions and intense biofouling due to higher light availability, which accelerates coating degradation and increases the risk of localized corrosion at surface defects. In response to these challenges, this study focuses on surface treatment strategies and advanced coating technologies for deep-sea aquaculture equipment, along with a comprehensive discussion of complementary corrosion protection methods. The aim of this paper is to develop an integrated corrosion prevention strategy based on coating protection in conjunction with other protective techniques, thereby reducing corrosion damage to marine ranching facilities and addressing the harmful by-products generated during corrosion processes. By systematically analyzing the surface and interfacial degradation behaviors of marine aquaculture equipment, this research provides practical guidance for the design of durable and environmentally adaptive surface protection systems, contributing to the sustainable development of deep-sea aquaculture infrastructure.

# sciforum-168476: A Comparison of Anti-Corrosive Performances of Phenolic-, Urethane-, THEIC-, Epoxy- and Silicone-Modified Alkyd Resins

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In this study, the anti-corrosive performances and coating properties of alkyd resins chemically modified with phenolic, urethane, THEIC (1,3,5-tris-(2-hydroxyethyl)isocyanurate), silicone and epoxy on metal surfaces were comparatively evaluated. Despite their advantageous properties in the paint industry, alkyd resins exhibit limited barrier performance against water, ions, and corrosion due to the hydrolysis-prone ester bonds in their structure. In order to eliminate this disadvantage, various chemical modification methods are recommended in the literature. According to the literature, in alkyd resins, phenolic modification creates an effective physical barrier against water vapor and chloride ions thanks to its dense cross-linked three-dimensional network structure. TDI-based urethane modification suppresses the susceptibility of ester bonds to hydrolysis, enhancing chemical stability, mechanical rigidity, and flexibility. It is believed that THEIC modification with trifunctional structure accelerates the curing kinetics and raises the glass transition temperature (Tg). Epoxy modification strengthens the hydrophobic characteristic, especially with alkali resistance. Silicon modification, on the other hand, significantly improves hydrophobic and environmental strength thanks to its low surface energy and high Si–O bond energy. In this study, phenolic-, urethane-, THEIC-, epoxy-, and silicone-modified alkyd resins were synthesized, and white paint recipes were prepared. The corrosion performance of these paints was evaluated by salt spray test. The physical and mechanical properties of the prepared paints were examined by drying time, gloss, König hardness, and adhesion (crosscut) tests. Surface hydrophobicity was evaluated by contact angle measurements, and morphological and structural features were determined by SEM, XRD, and FT-IR analyses. This study comparatively considers the corrosion resistance of different alkyd modifications. The results obtained revealed that the synthesized modified alkyd resins can exhibit good-to-excellent corrosion resistance under harsh environmental conditions. This research is expected to guide high-performance and alternative alkyd resin systems that can be developed in the future.

# sciforum-168453: A Sustainable Multi-Layer Anti-Corrosion Strategy for Magnesium Using a Surfactant to Strengthen Interlayer Adhesion

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Magnesium and its alloys are attractive structural materials due to their low density, high specific strength, and good castability and machinability, enabling their widespread use in transportation, aerospace, and biomedical applications. However, magnesium is highly reactive and therefore prone to rapid corrosion, which limits the durability and service life of magnesium-based components. Corrosion can occur through several mechanisms, including general, crevice, and microbiologically influenced corrosion. Environmentally acceptable inhibitors such as carbonates and cerium-based compounds are promising for slowing magnesium degradation, but further development is still needed.

In this work, a sustainable multilayer coating system was developed to improve magnesium corrosion resistance. A hydrothermally synthesised cerium carbonate hydroxide ($CeCO_3OH$) base layer was first applied, acting as a protective and pH-buffering passivation layer. To enhance adhesion and connectivity between layers, sodium dodecylbenzene sulfonate (SDBS) was introduced as an interfacial modifier. Finally, a biopolymer epoxy topcoat was applied to provide an additional physical barrier against electrolyte penetration. The optimal SDBS concentration was 0.05 M, facilitating the strongest interaction between the layered hydroxide and epoxy topcoat.

Scanning electron microscopy (SEM), energy-dispersive X-ray analysis (EDX), and X-ray diffraction (XRD) confirmed a highly crystalline $CeCO_3OH$ layer with high cerium content. Corrosion performance was evaluated using potentiodynamic polarisation and electrochemical impedance spectroscopy (EIS) in 3.5 wt % NaCl over a wide pH range (2–10). The best coating system ($Mg/LH/S_{0.05}/T$) showed excellent protection, with a very low corrosion current of 5.2 nA and a corrosion potential of –1.58 V. Strong corrosion resistance was maintained across pH 2.0 (5.5 nA) to pH 10.0 (2.0 nA). EIS results showed significantly increased impedance, low capacitance ($4.5 \times 10^{-11}$ F), and polarisation resistance of $3.6 \times 10^5$ Ω. The coating remained stable for up to 40 days, with gradual loss of protection observed after 40–50 days of immersion.

# sciforum-168619: Corrosion protection of AZ31B magnesium alloy using Ti-Zr thin films for biodegradable implant applications

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Biodegradable Mg alloys are attractive for temporary orthopedic implants because they can resorb in vivo, potentially eliminating the need for removal surgeries and reducing stress shielding due to their bone-like elastic modulus. However, clinical adoption is limited by rapid, non-uniform degradation that can compromise mechanical integrity, cause hydrogen gas evolution, and result in insufficient bioactivity for osseointegration. One effective strategy to address these limitations is the use of dense, adherent Ti–Zr-based thin films that serve as barrier/interfacial layers while preserving biocompatibility. In this context, we obtained Ti–Zr–X coatings (X = Cu, Nb, or CuNb) on AZ31B substrates (15 mm in diameter, 2 mm thick) by using unfiltered cathodic arc evaporation. Coating deposition was carried out at room temperature by using a substrate bias of –100 V and an Ar flow of 20 sccm, with composition-specific cathode currents and deposition times. Prior to corrosion-based investigations, structural and microstructural analyses were conducted to confirm the intended elemental composition. SEM observations revealed dense and homogeneous surfaces, while GIXRD results indicated a mixed crystalline microstructure for all Ti-based coatings, consisting of hexagonal TiZr, as well as tetragonal TiCu and/or cubic TiNb phases. Potentiodynamic measurements showed that the corrosion response strongly depends on coating chemistry, with the TiZrNb coating exhibiting the highest improvement in corrosion resistance among all investigated systems. This behavior was further supported by electrochemical impedance spectroscopy results, which revealed higher polarization resistance and more stable behavior for TiZrNb, indicating enhanced barrier properties and improved protection of the AZ31B substrate.

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# sciforum-167669: Corrosion Resistance and Functional Properties of Particle-Modified Plasma Electrolytic Oxidation Coatings on Metals

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Plasma Electrolytic Oxidation (PEO), also known as Micro Arc Oxidation (MAO), has recently attracted significant interest due to its ability to produce thick, well-adherent coatings with excellent corrosion and wear resistance. Key features of PEO coatings include the high porosity of the outer layer and the capability to incorporate particles dispersed in the electrolyte directly into the growing oxide layer. This latter feature enables functionalization of the coated surface and improves its corrosion properties.

In this study, PEO coatings were produced and characterized on aluminum and magnesium alloys by incorporating metallic and non-metallic particles. The coatings were synthesized using different current modes, namely direct current and pulsed unipolar current, with particle incorporation achieved by simple dispersion of the particles in the PEO electrolyte. Various types of particles were embedded in the coatings, including graphite nanoparticles to enhance wear resistance; metallic particles (copper or silver) to impart bactericidal, fungicidal, or antifouling properties; glass particles to improve wear and corrosion resistance; and titanium dioxide particles to generate photocatalytic surfaces. In all cases, the impact of particle incorporation on corrosion properties was also evaluated.

The resulting coatings were characterized on both the surface and cross-section using scanning electron microscopy (SEM) and X-ray diffraction (XRD) to confirm particle incorporation and to analyze the microstructure and morphology. Functional performance was further evaluated through corrosion, wear, biological, and photocatalytic tests, depending on the incorporated particles. In particular, corrosion properties were evaluated through electrochemical tests. In all cases, significant particle incorporation was achieved, resulting in coatings with enhanced, well-defined functional properties. In most cases, particle incorporation also leads to an improvement in corrosion properties.

# sciforum-173601: Electrochemical Impedance Spectroscopy Study of Corrosion Resistance of RF-Sputtered Titania Thin-Film-Coated SS316 in 3.5 wt.% NaCl

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Corrosion of stainless steel in chloride-containing environments remains a critical challenge for industrial applications, particularly in marine, chemical processing, and oil and gas systems, necessitating durable protection strategies. In this study, the corrosion behavior of AISI SS316 in 3.5 wt.% NaCl solution was investigated before and after application of titanium dioxide ($TiO_2$) thin-film coatings deposited using radiofrequency sputtering. The objective of this work was to evaluate the influence of a thin-film barrier on the electrochemical response and corrosion kinetics of stainless steel exposed to a simulated seawater environment.

Electrochemical Impedance Spectroscopy (EIS) and linear polarization techniques were employed to assess corrosion resistance and mechanisms of bare and coated specimens. Impedance measurements were conducted over a frequency range of 0.1 Hz to 1 MHz to evaluate coating integrity, charge transfer resistance, and capacitive behavior at the metal–electrolyte interface. Corrosion rates were determined using polarization resistance measurements and Tafel extrapolation methods to quantify kinetic parameters.

The EIS results demonstrated a significant increase in impedance and charge transfer resistance for $TiO_2$-coated SS316 compared to the uncoated substrate, indicating improved barrier properties and reduced electrochemical activity in chloride-rich solution. Linear polarization data confirmed a reduction in corrosion rate for coated specimens, validating the protective effectiveness of $TiO_2$ thin-film. Enhanced corrosion resistance is attributed to the formation of a dense and chemically inert $TiO_2$ layer that restricts electrolyte penetration and suppresses anodic and cathodic reactions on the stainless steel surface. The $TiO_2$ thin film also acts as a diffusion barrier limiting oxygen transport to the metal surface, reducing electrochemical activity at the metal–electrolyte interface. This behavior is relevant in chloride environments where localized corrosion mechanisms, including crevice corrosion, may be influenced by oxygen availability.

These findings highlight the potential of RF-sputtered $TiO_2$ thin-film coatings as a durable corrosion protection strategy for stainless steel components operating in chloride-containing environments.

# sciforum-161801: Forged and nitrided 316L stainless steel to mitigate corrosion in heat exchangers for water purification processes.

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Maintaining corrosion-free equipment in water purification processes is vital, as these processes aim to produce fresh water. Corrosion is a degradation process that affects metals, and heat exchangers are constructed from metals or alloys. This project analyzes and mitigates corrosion in 316L stainless steel heat exchangers that use lithium bromide (LiBr) as an absorber. These units are used in heat pumps for water purification. The effects of forging and nitriding processes will be studied on test specimens to evaluate their corrosion resistance, mechanical properties, and improved longevity. Subsequently, these processes will be applied to a full-scale heat exchanger. Twenty samples will be taken: five will be nitrided, five will be forged, and five will be both forged and nitrided. Both as-received and forged, nitrided, and nitrided-forged samples will be characterized for their mechanical behavior (wear, hardness, and tensile strength tests) and corrosion resistance using electrochemical techniques such as potentiodynamic polarization, electrochemical impedance, and electrochemical noise in a LiBr/$H_2O$ electrolyte. The expected results are an austenitic steel with high resistance to pitting corrosion, ideal for the heat exchanger industry, as developing materials to mitigate corrosion in this equipment remains a challenge. A scale-model heat exchanger will also be developed to assess its functionality over time.

# sciforum-177871: Influence of Surface Treatment on Hydrogen Embrittlement of Commercial Vehicle Seat Slider Bracket

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In the automotive industry, the selection of structural materials plays a critical role in ensuring component durability and performance. Among these, seats hold significant importance across all vehicle types—whether three-wheelers or four-wheelers. Based on the working mechanism, these seats can be hydraulic-based, spring-loaded or air suspension types, among others. Usually, high-strength steels are used to manufacture these seats. One such example is pneumatic seats, which are designed for multidirectional movement and are equipped with a seat slider assembly. Recently, we received a failed seat slider assembly from the plant. It was observed that the tooth of the locking bracket had completely broken off from the parent part.

The locking bracket features a toothed design which engages with the seat slider cavities to secure the seat position in multiple X-Y directions, ensuring movement of the seat. This part is manufactured using high-strength hot-rolled steel (SPFH 590 grade). Due to continuous engagement and repetitive cycles, the teeth are prone to wear; hence, carbonitriding surface treatment is applied to the toothed region to enhance surface hardness, achieving a hardness range of 625–725 HV.

During fractography analysis, intergranular fracture, along with multiple cracks, was observed. A study of the manufacturing and heat treatment process revealed that the part undergoes case hardening during carbonitriding, along with ammonium–hydrogen gas mixture exposure, which results in hydrogen pickup. This hydrogen diffuses inside the material and accumulates on the grain boundaries, eventually weakening them, which can further lead to intergranular fracture. To further mitigate the issue, the amount of diffusible hydrogen needs to be decreased, which can be achieved by increasing the tempering temperature to 250 °C–300 °C.

# sciforum-168666: Multifunctional Ionic Polymer Coatings with Self-Healing and Photocatalytic Activity for Aluminum Alloy Corrosion Protection

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Organic protective coatings are extensively employed to reduce the corrosion of metallic materials in a wide range of industrial applications. However, mechanical defects such as scratches, pinholes, and microcracks can significantly impair their barrier properties, providing pathways for aggressive species and promoting the onset of localized corrosion. In the present work, supramolecular and thermoplastic ionic polymers containing carboxylic acid functionalities, partially or fully neutralized with metal ions, were synthesized and deposited onto aluminum alloy substrates. These coatings were designed to impart enhanced anticorrosive performance while simultaneously exhibiting self-healing and photocatalytic capabilities. Surface topography, coating integrity, and corrosion-related degradation were systematically analyzed using scanning electron microscopy and atomic force microscopy. Interfacial interactions, elemental distribution, and complex formation within the coatings were examined through energy-dispersive X-ray spectroscopy and X-ray diffraction analyses. The photocatalytic performance of the coatings was evaluated under controlled light exposure, revealing effective self-cleaning behavior without compromising coating adhesion or structural stability. Corrosion resistance was assessed using open-circuit potential measurements, potentiodynamic polarization, and electrochemical impedance spectroscopy in aggressive corrosive environments. Autonomous self-healing behavior was investigated by introducing artificial defects into the coatings, with the recovery process monitored using in situ Raman spectroscopy and electrochemical impedance spectroscopy. The developed composite coatings demonstrated a progressive increase in impedance modulus and polarization resistance with immersion time, confirming durable corrosion protection. Overall, the results highlight the successful integration of corrosion resistance, self-healing ability, and photocatalytic functionality within a single coating system.

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# sciforum-173476: Nanosecond Laser Texturing of Triple-Scale Surface Structuring for Robust Pitting Corrosion Resistance in AA6061

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Aluminum alloys such as AA6061 are widely deployed in marine and chloride-containing environments but remain vulnerable to localized pitting corrosion once the native oxide film is destabilized. This work presents a scalable, PFAS-free surface engineering strategy that suppresses pitting corrosion through nanosecond laser manufacturing of triple-scale hierarchical architectures combined with siloxane-based chemical functionalization. Nanosecond IR laser texturing generates fully covered grid and grid-plus-double-diagonal (G+DD) patterns consisting of micron-scale trenches and ridges, submicron resolidified features, and nanoscale cauliflower-like structures enriched with aluminum oxide. This multiscale roughness increases the effective surface area, enhances oxide density, and promotes robust chemical anchoring of a non-fluorinated OTS–PDMS hybrid layer, which lowers surface energy while maintaining mechanical stability. The optimized (LT (GDD) + CT) surface exhibits stable Cassie–Baxter wetting behavior with a static water contact angle of ~158°, advancing and receding angles above 159°, a roll-off angle of ~2°, and an ultra-low normalized surface free energy of ~5.6 mN $m^{-1}$, indicating strong suppression of polar interactions and reduced electrolyte affinity. Electrochemical characterization in 0.6 M NaCl reveals a pronounced positive shift in pitting potential and orders-of-magnitude increases in low-frequency impedance magnitude and polarization resistance relative to bare, chemically treated-only, and laser-only controls. Time-dependent electrochemical impedance spectroscopy conducted over 17 days demonstrates sustained high corrosion resistance and minimal degradation of the hierarchical morphology. Post-immersion microscopy confirms limited localized attack and preserved surface features on the fully textured and functionalized surface, whereas partial-coverage or single-treatment samples exhibit evident pitting and surface breakdown. The results demonstrate that process-driven nanosecond laser texturing coupled with PFAS-free siloxane functionalization provides a manufacturable, industry-compatible route to durable, non-wetting, highly robust, and sustained corrosion-resistant aluminum surfaces suitable for aerospace, marine, and transportation applications without reliance on fluorinated chemistry.

# sciforum-181086: Non-contact Evaluation of Coating System Re-deterioration in Steel Sheet Pile Canal

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In drainage canals, steel sheet piles are known to be susceptible to localized corrosion, particularly around water level fluctuation zones. In Japan, various repair methods have been applied to extend the service life of existing facilities. However, some repaired steel sheet piles exhibit further deterioration. In this study, the feasibility of evaluating re-deterioration is investigated in an agricultural drainage canal, where further deterioration of the repaired coating system has progressed, using image data acquired by unmanned aerial vehicles (UAVs) and from the ground. The investigated canal had been repaired using several coating materials, including an ultra-thin urea-urethane coating, thin-film epoxy resin coating, ultra-thick polyurethane-resin coating system, and precast concrete panel lining system. Both image data and the on-site visual inspection indicate that the deterioration condition varies depending on the repair method, and different types of defects are identified for each repair method. Deteriorations such as blistering, delamination, peeling, rust staining, and cracks in the concrete panel are observed. These results suggest that image data can provide basic information for evaluating characteristics of re-deterioration after repair. In future work, point cloud data acquired by UAVs will also be incorporated to quantify the degree of deterioration and to further refine the evaluation method.

# sciforum-168551: The use of DFT first principles and FactSage simulation methods to predict the phase stability of FCC Ni-Cr-Al alloys in an attempt to improve metal dusting resistance in the petrochemical industry

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This work explored the use of density functional theory (DFT) first principles and FactSage simulations to predict suitable Ni-Cr-Al alloy compositions that can be used in the petrochemical industry. Currently, there is a need for improving production efficiency in the petrochemical industries, resulting in the use of higher operating temperatures and pressures, as well as higher levels of carbon dioxide ($CO_2$). High-temperature operations results in metal pitting that occurs in carbon supersaturated gaseous environments at temperatures ranging from 400 to 850°C. The simulated phase diagrams of Ni-Cr, Ni-Al and Ni-Cr-Al alloys showed that the stable phases were found to be BCC and FCC. BCC is chromium (Cr)-dominant, and FCC is nickel (Ni)-dominant. The Gibbs free energy of the alloys shows that the alloys are thermodynamically stable at 650°C. CASTEP simulation was used to calculate the mechanical properties of Ni-Cr-Al alloys using the supercell approach. From the calculations, we can see the suitable working range for Cr is between 18.25 and 25 at.%, and with Al 6.25 at.% it showed to be the best alloying concentration for the ternary alloy. The metal dusting results showed that with CO exposure, the alloys experience carbon attack at low CO exposure, due to a minimum amount of oxide layer that is present. With the exposure to CO-$H_2$-$H_2O$, all samples had oxide layers that formed. It can be concluded that Ni - 30.67 at.% Cr - 6.25 at.% Al performed better as a metal dusting resistance alloy when exposed to CO and CO-$H_2$-$H_2O$ at 525 and at 650°C.

# sciforum-168599: Towards an Easy Electrochemical Method for Evaluating Sealing Quality of Anodized Aluminium

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**Abstract:** A variety of methods are employed for evaluating the sealing quality of anodized aluminium. These tests are based on various mechanisms, can be qualitative or quantitative, and vary in the level of detail and preparation necessary to obtain good results. In this work, we evaluate a variety of electrochemical methods (electrochemical impedance spectroscopy (EIS), potentiodynamic polarization, and open circuit potential (OCP) evolution with time measurements) as candidates for sealing quality evaluation. The desirable criteria for a target electrochemical test method are that it is non-destructive, requires little or no prior sample preparation, is applicable to long anodized profiles, is completed in a short time, and yields results that are interpretable with very little or no post-test data processing. Selected electrochemical tests were carried out on sulphuric acid anodized AA6060 aluminium alloy samples hydrothermally sealed at a constant time (30 minutes) in de-ionized water at varying temperatures, 50˚C, 60˚C, 70˚C, 80˚C, 90˚C, and 98 ˚C, respectively. The feasibility of a simple electrochemical method (OCP evolution) for evaluating the barrier properties (corrosion resistance) of sealed and partially sealed anodized aluminium samples is demonstrated.

Ackowledgements

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# Session 4. Corrosion in New Materials (HEA, CCA, TWIP/TRIP, AM, PM)

# sciforum-166702: Evaluation of Al additions to high-entropy alloys as structural material for the next generation of CSP plants

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Molten salt technology using nitrate salts in tubular external receivers is the current state-of-the-art in concentrated solar power (CSP) technology, but new molten salts chemistry, using carbonates and chloride salts, has been proposed in order to increase the TES temperature and improve the turbine block efficiency. The selection of a high-temperature molten salt chemistry is necessary, alongside the need to understand its impact on new containment materials, to achieve acceptable strength, durability, and cost targets at these high temperatures. In this direction, the aim of this work is to explore different high-entropy alloys (HEAs) to evaluate their corrosion resistance in contact with carbonate and chloride molten salts at 650 and 720°C, respectively. HEAs exhibit a unique combination of properties attributed to four core effects: high mixing entropy, lattice distortion, sluggish diffusion, and cocktail effect. In particular, the equiatomic, single-phase, face-centered cubic (FCC) CrMnFeCoNi Cantor alloy has garnered significant attention for its exceptional thermodynamic stability and remarkable resistance to corrosive environments.

In this study, three cantor alloys with different Al additions and a Nickel base alloy (In702) were exposed to the eutectic ternary $Li_2CO_3$–$K_2CO_3$–$Na_2CO_3$ (32.1–34.5–33.4 wt%) salt mixture at 650 °C for 500 hours, as well as to ternary chloride salt, composed of 20.4 KCl + 55.1 $MgCl_2$ + 24.5 NaCl at 720°C under inert atmosphere ($N_2$). A special setup was designed in order to integrate electrochemical electrodes into the corrosion reactor to carry out electrochemical impedance spectroscopy (EIS) tests and linear polarization resistance (LPR) during the isothermal immersion.

Lower corrosion rates (0.28mm/year) were obtained for Cantor C alloy with a higher addition of Al, improving the corrosion resistance of In702 in the molten salt selected. In this case, the addition of Al to CrMnFeCoNi alloy improves the corrosion resistance significantly due to the protective layers formed as $NiAl_2O_4$, $MgFeAlO_4$.

# sciforum-159721: Investigating the Mechanical and Corrosion Properties of Ti 21S Produced via Laser Powder Directed Energy Deposition: A Viable Alternative to Ti-6Al-4V for Biomedical Implants

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The increasing prevalence of implants is parallel to the global aging population. Titanium alloy Ti-6Al-4V (Ti 64) is widely utilized in biomedical applications; however, concerns regarding aluminium (Al) and vanadium (V) ion release and their potential long-term effects on human health are prompting the exploration of alternative materials. Among these, β-titanium alloys that are free of Al and V are being investigated. Ti 21S, a metastable β-titanium alloy, demonstrates a lower Young's modulus that aligns more closely with the mechanical properties of human cortical bone, thereby mitigating the issue of stress shielding. In this study, Ti 64 and Ti 21S were fabricated using laser powder directed energy deposition (LP-DED), and their properties, including density, microstructure, hardness, and corrosion behaviour in a 0.9% NaCl solution, were assessed. Optimized LP-DED parameters for Ti 21S yielded over 99.9% of theoretical density, a fully β microstructure, uniform hardness, and stable passivation with low corrosion currents, indicating strong resistance to corrosive degradation. These findings confirm that Directed Energy Deposition can successfully produce high-quality Ti 21S while maintaining its advantageous properties. Overall, Ti 21S exhibits corrosion performance at least comparable to that of Ti 64 while offering a mechanical response characterized by a lower modulus closer to that of bone. In light of the increasing demand for durable implants in an aging population, Ti 21S presents a promising alternative to Ti 64 for future biomedical applications.

# sciforum-155671: Oxidation behaviour of a CrCoNiAlTi multicomponent alloy

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Multi-component metallic alloys, such as high-entropy alloys (HEAs), have recently attracted scientific and industrial interest due to their capacity to be used in a variety of applications, especially as potential candidates for high-temperature services. In this study, the oxidation behavior of CrCoNiAlTi alloy was investigated at different temperatures and exposure times.

Oxidation tests were carried out in a tubular furnace in atmospheric air. Samples were tested at 800°C, 900°C and 1000°C and subjected to exposure times of 5 h, 24h and 48 h at each temperature. Microstructural characterization was performed by X-Ray Diffraction (XRD) scanning electron microscopy (SEM) coupled with energy-dispersive X-ray spectroscopy (EDS).

XRD revealed the presence of a hexagonal close-packed corundum-type phase, which might consist of both alumina and/or chromia, as both oxides present similar trigonal crystal structures. SEM analysis, supported by EDS, indicated the presence of an inner layer of Al2O3 and an external layer of Cr2O3. Mass gain calculations investigated the oxidation rate law. In this case, a parabolic rate law was observed in all tested samples, which suggests a diffusion-controlled process along the different time intervals and the possibility of formation of stable oxide scales. The observed mass gain for the 48 h time interval (which was the most significant oxide scale production interval), for example, included values ranging from 0,228 mg/cm$^2$ (at 800°C) to 0,679 mg/cm$^2$ (at 900°C) to 1,941mg/cm$^2$ (at 1000°C), showing a notable enhancement in scale production at the higher temperature of 1000°C. In fact, that significant increase in scale formation can be determined by the calculated equilibrium constant (Kp) when one compares the Kp at 800°C = 1,20 x 10$^{-3}$ mg$^2$cm$^{-4}$h$^{-1}$ and the Kp at 1000°C = 4,59 x 10$^{-3}$ mg$^2$cm$^{-4}$h$^{-1}$.

These results present a starting point for understanding the oxidation kinetics of CrCoNiAlTi multicomponent alloys.

# Session 5. Corrosion in Biomedical Implants

# sciforum-167252: A comprehensive assessment of the effect of bovine serum albumin on the stress corrosion cracking and corrosion behaviour of Mg-Ca alloy

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Magnesium–calcium (Mg-Ca) alloys have emerged as promising candidates for temporary bio-implant applications due to some notable mechanical, biodegradability and biocompatibility properties. However, the corrosion behavior of Mg-Ca alloy, especially in protein-containing physiological environments, remains insufficiently understood. This study investigates the effect of bovine serum albumin (BSA) addition to Hank's Balanced Salt Solution (HBSS) on the corrosion and stress corrosion cracking (SCC) behavior of Mg-Ca alloy. A combination of potentiodynamic polarization (PDP), electrochemical impedance spectroscopy (EIS), and surface characterization techniques—optical microscopy (OM), scanning electron microscopy (SEM), energy dispersive X-ray spectroscopy (EDS), X-ray photoelectron spectroscopy (XPS), and attenuated total reflectance Fourier-transform infrared spectroscopy (ATR-FTIR)—were employed. The results indicate that BSA adsorption on the alloy surface initially inhibits dissolution, reducing corrosion rates during the first 24 hours. However, prolonged immersion leads to enhanced corrosion, driven by the chelation of BSA with $Ca^{2+}$ ions, which induces cracks in the surface film and promotes alloy dissolution. Furthermore, the fractography reveals that the Mg-Ca alloy is susceptible to SCC in an HBSS environment. However, no evidence of SCC was observed in the HBSS+BSA environment. These findings provide new insights into the complex interactions between proteins and Mg-based implants, contributing to the design of more reliable temporary bio-implant materials.

# sciforum-173546: Corrosion and Tribocorrosion Behaviour of Wrought and LPBF Ti-6Al-4V Alloys for Biomedical Applications

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Laser powder bed fusion (LPBF) is increasingly adopted for manufacturing Ti-6Al-4V biomedical alloy, yet the rapid solidification produces martensite that may influence corrosion, mechanical performance, and tribocorrosion in physiological environments. This study provides a comparison between wrought (WR) and LPBF Ti-6Al-4V alloys to assess the suitability of LPBF material for biomedical applications. Microstructural characterization revealed that WR Ti-6Al-4V exhibits a lamellar $\alpha+\beta$ structure with coarse grains, whereas LPBF consists of fine $\alpha'$-martensite and a 10-times smaller grain size. Nanoindentation testing showed that LPBF specimens possess a one-third higher hardness and significantly higher yield strength, while WR alloy demonstrates greater ductility. Electrochemical testing in simulated body fluid (SBF, 37 °C) confirmed very low corrosion rates ($10^{-5}$ mA/cm$^2$) and stable passivity for both alloys, with no localized corrosion; however, LPBF exhibited slightly higher passive currents and occasional metastable pitting, attributed to their martensitic structure and elevated defect density. Under dry sliding, LPBF Ti-6Al-4V demonstrated ~14% lower wear rate and marginally lower friction. In SBF, wear increased for both alloys, and their wear resistance converged due to tribocorrosion synergy. The LPBF alloy showed a stronger coupling between mechanical damage and electrochemical activity, more intensive wear-accelerated corrosion, and faster depassivation–repassivation cycling within the wear track. These effects amplified material removal despite higher hardness, whereas the WR showed a more balanced interaction between mechanical wear and corrosion. Generally, LPBF Ti-6Al-4V combines high strength, good wear resistance, and excellent corrosion performance, confirming its suitability for implants, while post-processing heat treatments may further optimize its tribocorrosion response.

# sciforum-179957: Effect of Different Annealing Temperatures on the Phase Analysis, Microstructures and Corrosion Resistance of Binary Ti-Cu Alloys

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One of the key challenges confronting the use of implant materials is degradation, which occurs when the biomaterial interacts with the human body physiological fluids. This degradation is referred to as corrosion; hence, corrosion resistance is one of the vital properties the implant material should possess. Among the few biocompatible and most promising implant materials for long-term use is titanium (Ti) and its alloys, which have been extensively applied in various fields due to their excellent mechanical properties, and promising corrosion resistance. Alloying Ti with small amounts of copper (Cu) does not only increase the strength and corrosion resistance but also exhibits antibacterial properties which are beneficial to implants transplants. In this study, two Ti-Cu alloys containing 5 and 10 weight percent (wt.%) compositions of Cu were produced using an arc-melting process under a controlled inert atmosphere. The cast ingots were annealed at 900 ℃ and 1050 ℃ for 2h followed by furnace cooling. Samples were cut into thin plates of about 3mm thickness and undergone phase, microstructural and electrochemical analyses. Characterisation using XRD and SEM-EDX techniques revealed strong presence of the α-Ti(Cu) phase forming below the eutectoid point and hypereutectoid intermetallic $Ti_2Cu$ phase. The size and volume fraction of intermetallic phase was found to increase with both Cu content and increase in the annealing temperature. In summary, this study demonstrates a correlation between phase, morphology and corrosion resistance. Particularly, the XRD, SEM-EDX and the corrosion tests showed that, as the Cu content and annealing temperature increased in the binary Ti-Cu alloys, the amount and size of intermetallic phase(s) increased, corresponding with significantly improved corrosion resistance performance. Current results validate our recent theoretically formulated mechanism that links the alloy oxidation state to corrosion resistance, an indication that both the α-Ti and intermetallic phases contribute towards the improved corrosion resistance.

# sciforum-173525: Improving Corrosion Resistance of AZ31 Alloy using Zr/Si Sol–Gel Coating in Simulated Body Fluid

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Recent advances in biomedical engineering have highlighted the potential of biocompatible metals, particularly magnesium alloys, for temporary implant applications. These materials are designed to degrade in physiological environments, eliminating the need for secondary surgical removal. However, their corrosion rate often exceeds the rate of tissue healing, limiting clinical applicability and requiring effective strategies to better control degradation [1].

This study presents the development of a Zr–Si hybrid sol–gel coating aimed at enhancing corrosion resistance and regulating the degradation behaviour of AZ31 magnesium alloy. The coatings were synthesised from tetraethyl orthosilicate (TEOS) and the organically modified silane 3-methacryloxypropyltrimethoxysilane (MAPTMS). Zirconium(IV) propoxide (ZTP), chelated with methacrylic acid (MAA), was incorporated to tailor the inorganic–organic network structure and optimise protective performance [2]. The evolution of the sol–gel system was monitored by in situ Fourier transform infrared spectroscopy (FTIR), while surface morphology and elemental composition were characterised using scanning electron microscopy coupled with energy-dispersive spectroscopy (SEM/EDS).

Corrosion performance was evaluated in simulated body fluid (SBF) using potentiodynamic polarisation and electrochemical impedance spectroscopy. Degradation kinetics in SBF were further assessed by hydrogen evolution during immersion.

The developed hybrid coatings improved corrosion resistance and effectively moderated magnesium degradation in simulated physiological conditions, demonstrating the potential of Zr–Si hybrid sol–gel systems for controlled resorption of magnesium-based implants.

Acknowledgements

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# sciforum-173378: Investigation of Biodegradability of Wrought Mg-Ca-Mn Alloy as a Potential Material for Urological Applications

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After numerous surgeries in the urinary system, stenting is often required to ensure complete urine discharge, prevent urine from flowing back into the kidneys, and maintain proper urine flow to avoid renal failure. The stents currently used in medical centers are primarily polymeric. Over time, the surface of these stents becomes covered with a crystalline layer and bacterial colonies, which, without secondary care, leads to reduced mechanical properties and potential infection. To address these issues, biodegradable stents have been introduced as an alternative. This research investigates the magnesium alloy, specifically the Mg-Ca-Mn alloy, as a biodegradable material for this purpose. Given the limited formability of magnesium alloys, rolling was selected as the fabrication method for the stents. Samples were rolled from an initial thickness of 5.0 mm down to 0.4 mm with a preheating duration of 10 minutes. The grain size of the specimens after rolling was significantly reduced from 200 ± 30 µm to 17 ± 5 µm. This reduction in grain size resulted in a notable increase in yield and ultimate tensile strength, from 108.30 ± 3.60 MPa to 231.45 ± 17.17 MPa. The microstructure and texture of the material were evaluated using optical microscopy, X-ray diffraction, and electron backscatter diffraction. The results indicate a significant reduction in grain size following rolling, along with changes in dislocation density and texture, as revealed by EBSD data. These factors contribute to a higher surface potential, leading to a higher corrosion rate in the initial seconds of the corrosion process. Nevertheless, a protective layer forms rapidly, thereby controlling the corrosion rate sooner and resulting in lower rates over time. The average corrosion rates calculated from hydrogen evolution and weight loss studies in artificial urine over 14 days, and from polarization assessments, were 0.889 mm/y, 1.616 mm/y, and 2.402 mm/y, respectively. Consequently, the stent produced through this process is expected to fully degrade within 10-12 weeks.

# sciforum-181178: Point Defect Model, PDM: Predicting metallic implant lifetime—what we did and what we will do!

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Orthopedic implant lifetime is a key health issue for patients. One in thirty Americans has an orthopedic prosthesis. In Europe, this number is not available but according to sales made by companies, this figure is likely on the same order of magnitude. Metals, stainless steels, titanium alloys, and Cobalt Chromium Molybdenum alloys used for implants must have the specificity to resist under liquid environments during usage, corrosion–friction–fretting, etc. It is worth noting that additive manufacturing is currently progressing but for implants, usual manufacturing processes are always used. Highlighting both the best mechanical and materials parameters in cases of degradation is the aim of this study, using the Point Defect Model. Contact mechanics between stainless steel and poly-mthylmetacrylate, PMMA, have been focused on. Two types of experiments were investigated: Free corrosion potential or open circuit potential and applied potential. Describing behaviors in terms of the wear and morphologies of the wear track area is the key point of this study. The authors paid attention to a synergistic approach, evaluating the contribution of wear to corrosion and vice versa. Theoretical and practical issues are related to understanding these phenomena and predicting passive film thickness. There were a few nanometers of oxides on the top surface and the material behavior depended on a few nanometers.

# Session 6. Corrosion and Integrity Management in Energy Infrastructure

# sciforum-173536: Decoupling Oxygen Content and Corrosivity in HTL Bio-Oils through Speciation and Structural Embedding

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Hydrothermal liquefaction (HTL) products often contain substantial oxygen, which is conventionally associated with high total acid numbers (TAN), corrosion, and chemical instability. However, certain HTL bio-oils exhibit remarkable stability despite comparable or higher oxygen content relative to pyrolysis oils. Here, we investigate the role of oxygen accessibility, speciation, and molecular integration in governing the corrosion behavior and chemical stability of solid and highly viscous HTL products. Bulk elemental analysis reveals that oxygen content alone is a poor predictor of TAN and corrosivity. It is worth noting that thermogravimetry and chromatography analysis specifically demonstrate a scarcity of low-molecular-weight, volatile oxygenates in HTL products, indicating limited chemical accessibility. Further, solvent extraction experiments reveal that only a minor fraction of oxygenates is accessible, which rather limits their participation in corrosion reactions. These findings support a mechanistic framework in which oxygenated intermediates generated during HTL undergo condensation and structural embedding, suppressing the formation of reactive low-molecular-weight acids. Consequently, HTL products retain high oxygen content while exhibiting low TAN, negligible corrosion, and truly enhanced chemical stability. This study emphasizes that oxygen speciation and molecular integration, rather than total oxygen content, govern the stability of HTL bio-oils, providing a rationale for direct functionalization without extensive deoxygenation.

# sciforum-171348: Failure Investigation of a Duplex Stainless Steel Flange: Role of Improper Heat Treatment and Sigma Phase Embrittlement

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Duplex stainless steels (DSSs) are widely used in pressure-retaining components due to their high strength, toughness, and corrosion resistance arising from a balanced ferrite–austenite microstructure. However, exposure to inappropriate thermal conditions during fabrication or heat treatment can promote precipitation of intermetallic phases, particularly sigma (σ) phase, which severely degrades fracture toughness and corrosion performance. This study presents a detailed failure investigation of a DSS flange that fractured during hydrostatic pressure testing.

The failure investigation comprised visual examination, fractography, optical microscopy, scanning electron microscopy (SEM) with energy-dispersive spectroscopy (EDS), hardness mapping, ferrite content measurement, Charpy V-notch impact testing, and ASTM G48 corrosion testing. Material traceability records were reviewed to correlate metallurgical observations and property variations across different heat numbers supplied for identical service conditions.

Microstructural analysis revealed extensive sigma phase precipitation along ferrite–austenite interfaces in the failed flange, accompanied by chromium and molybdenum segregation consistent with intermetallic phase formation. Ferrite measurements indicated deviation from the recommended phase balance for DSS. Charpy impact testing showed a pronounced reduction in absorbed energy, confirming severe embrittlement, while ASTM G48 testing demonstrated localized corrosion attack associated with chromium-depleted regions. Fractographic examination revealed chevron patterns characteristic of rapid brittle fracture, with crack initiation associated with sigma-rich embrittled regions and unstable propagation during hydrostatic loading. Comparative assessment across multiple heat numbers demonstrated that these degradations were confined to a single material batch, whereas components from other heats exhibited acceptable microstructure, toughness, and corrosion resistance.

The combined evidence of intermetallic precipitation, microchemical segregation, mechanical embrittlement, corrosion susceptibility, and batch-specific occurrence indicates improper thermal exposure during heat treatment of the affected heat number as the root cause of failure. Sigma phase–induced embrittlement significantly reduced fracture toughness, causing brittle failure during hydrotesting. The findings highlight the critical importance of strict thermal process control, heat number traceability, and phase balance verification.

# sciforum-165984: Mechanisms of Early-Stage Stress Corrosion Cracking

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Stress corrosion cracking (SCC) is a critical degradation process in structural materials exposed to service-relevant environments, yet the mechanisms governing early stages of crack development remain insufficiently understood. In this work, the early-stage SCC behavior of pipeline steels exposed to groundwater environments is investigated. Emphasis is placed on the initiation and evolution of surface cracks prior to the onset of steady-state crack growth. Experimental observations indicate that early-stage crack growth is not dominated by the random nucleation and coalescence of independent microcracks, but is instead strongly influenced by localized deformation and environmental interactions within the plastic zone ahead of existing surface cracks. Under load-controlled conditions, transient increases in the local strain rate may arise from material yielding behavior or the exhaustion of time-dependent deformation processes, promoting surface film rupture and localized dissolution. Consequently, new microcracks preferentially form near the surface and subsequently link with the main crack, leading to crack extension primarily along the surface direction while crack depth remains limited. This process progressively increases the stress intensity factor at the crack tip in the depth direction and facilitates the transition to rapid crack growth. These findings highlight the importance of early-stage deformation behavior and localized electrochemical activity in controlling SCC evolution and suggest that mitigating early crack growth may significantly extend the service life of structural materials operating under conditions conducive to SCC.

# sciforum-179085: A laser-polished subsurface microstructural barrier mitigates hydrogen embrittlement in high-pressure hydrogen environments

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Hydrogen embrittlement (HE) is a critical bottleneck that limits the safe transport of hydrogen through existing steel pipelines and hinders the widespread use of hydrogen as a clean energy carrier. This work demonstrates that laser polishing (LP) can significantly improve the HE resistance of X80 pipeline steel in a high-pressure $H_2$ environment, primarily by constructing a subsurface microstructural barrier rather than merely smoothing the surface. By systematically adjusting the laser power (6–20 W) and the number of processing passes, an optimal heat input window (10 W) was identified, wherein the microstructure of the modified layer was optimized. This resulted in a gradient transition layer consisting of ultrafine nanograins near the surface, lath-shaped nanograins, and an underlying heat-affected zone (HAZ), along with a synergistic increase in dislocation density and interface/trap density. The more uniform grain-size transition caused by multiple passes effectively reduced the risk of interfacial hydrogen embrittlement due to the mismatch in physical properties between the modified layer and substrate. This artificially constructed subsurface barrier effectively reduces hydrogen diffusion and permeation, as indicated by the lowest apparent diffusion coefficient ($D_{app}$) observed at 10 W, which further decreases with multiple passes. Slow-strain-rate tensile tests conducted in high-pressure $H_2$ showed a significant reduction in elongation loss ($I_\delta$) and an increase in absorbed energy, both closely linked to microstructural changes. Fractographic analysis revealed a shift in fracture mode toward a more ductile behavior, with enhanced local plasticity, consistent with the HELP mechanism. Notably, the best HE resistance was achieved even with the highest surface roughness, indicating that HE mitigation depends more on subsurface barrier integrity than surface topography alone. This work offers mechanistic understanding and a practical surface-engineering approach for developing hydrogen-resistant pipeline steels, with direct benefits for safely and economically converting existing infrastructure for hydrogen transport.

# sciforum-173551: Atmospheric corrosivity in a bagasse/coal co-firing power plant influenced by a tropical marine climate

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Introduction

Combined marine and industrial conditions form a complex climate that complicates corrosion prediction in energy infrastructure design. The impact of pollutant mix, driven by wind action and high humidity, may affect the evolution of corrosion product formation. This study provides valuable insights into the corrosivity of a unique marine-industrial location on the tropical island of Mauritius.

Methods

S235-grade carbon steel plates are subjected to a 14-month atmospheric exposure test at a bagasse/coal thermal power plant situated 3 km from the tropical coastal sea. Weight loss analysis is performed with triplicate specimens retrieved at specific time points to determine the corrosion kinetics. Furthermore, surface analysis using SEM-EDS and FTIR helps to identify the rust phases.

Results

The results demonstrate a corrosion rate (340 $gm^{-2}a^{-1}$) in the medium ISO 9223 category (C3). The chloride ($Cl^-$) deposition rate is elevated at 74 mg $m^{-2}$ $d^{-1}$ but does not cause the formation of flaky corrosion layers. Lepidocrocite (γ-FeOOH) and goethite (α-FeOOH) are the predominant rust phases. Also, sulphur dioxide ($SO_2$) emissions do not lead to significant surface deposition, mainly due to the low sulphur content of bagasse and the location of the gas stack relative to the exposure rack.

Conclusion

Formation of stable corrosion products, such as (α-FeOOH), limits $Cl^-$ penetration due to the inherently compact and dense rust layer. Extreme corrosion protection measures may not be required in bagasse/coal cogeneration plants. However, higher times of wetness and lower $SO_2$ emissions may lead to conditions more conducive to chloride attack in a marine region.

# sciforum-168538: Comparative Study on SRB-Induced Corrosion of 90/10 Copper-Nickel Alloy Welded Joints: Anaerobic Bulk Immersion vs. Thin Liquid Film Environments

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As a critical vulnerability in the piping systems of energy facilities, the structural integrity of copper–nickel (Cu-Ni) alloy welded joints under microbial environments has garnered significant attention. This study investigates the divergent corrosion behaviors of 90/10 Cu-Ni alloy welded joints induced by sulfate-reducing bacteria (SRB) through simulated experiments, comparing bulk immersion and thin liquid film (TLF) environments. The results demonstrate that under identical SRB inoculation concentrations, the localized corrosion of welded joints is significantly intensified in the TLF environment. Notably, the average depth of intergranular corrosion (IGC) trenches in TLF is approximately 50% greater than that observed in bulk immersion. This acceleration effect is primarily attributed to the restricted diffusion of metabolic products within the confined liquid phase space of the TLF. Mechanistic analysis reveals that despite the strictly anaerobic conditions, the limited volume of the TLF leads to the drastic enrichment of SRB cells and their metabolic sulfides ($HS^-$) at the weld metal (WM) and heat-affected zone (HAZ), triggering severe localized MIC. Electrochemical Impedance Spectroscopy (EIS) further confirms that the sulfide-based corrosion product films formed under TLF exhibit higher porosity and lower charge transfer resistance, failing to provide effective passivity. This work elucidates the MIC evolution patterns under the specific service condition of anaerobic thin liquid films, offering a novel perspective for risk identification and integrity management of critical energy infrastructure components.

# sciforum-179847: Corrosion Behavior of ASTM A36 Steel in Antarctic Marine and Glacier Waters: An Electrochemical and Gravimetric Study

**Raúl Dávalos Monteiro [1], Christian Narváez-Muñoz [2], Carlos Loyo-Dávila [3], Gabriela Ruiz-Hinojoza [1], Ibeth Rendón-Enríquez [1], Julio Chacón-Torres [4]**

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**Introduction:**

Corrosion behavior of structural steels in extreme environments remains insufficiently understood, particularly in Antarctic conditions where low temperatures, variable salinity, and high oxygen solubility may significantly influence degradation mechanisms. This study investigates the in situ corrosion performance of ASTM A36 steel in Antarctic marine and glacier waters to provide insight into material durability in polar environments.

**Methods:**

Electrochemical characterization was conducted using techniques such as open-circuit potential, linear-sweep voltammetry, and electrochemical impedance spectroscopy in both Antarctic seawater and glacier water. Complementary gravimetric analysis was performed using weight-loss measurements during controlled exposure periods. Surface and microstructural characterization of the corroded samples was carried out using scanning electron microscopy after the specimens were transported from Antarctica to the laboratory.

**Results:**

Electrochemical results revealed distinct corrosion behaviors between the two environments, with active corrosion activity observed in marine water, attributed to increased ionic conductivity and chloride content. Glacier water exhibited important electrochemical activity, and general corrosion attack was detected. Gravimetric measurements were consistent with electrochemical findings, confirming mass loss in glacier and marine waters. SEM analysis revealed the formation of heterogeneous corrosion products and localized degradation features, which correlate with the electrochemical data.

**Conclusions:**

The combined electrochemical and gravimetric approach demonstrates that Antarctic environmental conditions significantly affect corrosion mechanisms of ASTM A36 steel. Marine exposure accelerates corrosion due to salinity, while glacier water promotes measurable degradation and the formation of corrosion products across the surfaces. These findings contribute to understanding material performance in polar regions and support the design of more durable infrastructure for extreme environments.

# sciforum-168192: Corrosion-Resistant and Conductive Coatings for Metal Bipolar Plates in Proton Exchange Membrane Fuel Cells

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Introduction

Developing corrosion-resistant and conductive coating coatings is essential to promote the application of metal bipolar plates (BPs) in proton exchange membrane fuel cells (PEMFCs). This report summarizes the research achievements of our group over the past decade, covering metal substrates, nitrides coatings, precious metal coatings, and specifically, oxide coatings and amorphous carbon/metal (a-C/Me) composite coatings.

Methods

To balance performance and costs, C/Ti, ML-C/Ti and ML-C/Cr coatings were designed via introducing transition layers and designing alternating multilayer structures.

Results

The multiple diffusion interfaces optimize the potential distribution to improved transpassivation potential ($E_{tp}$). In particular, the $E_{tp}$ of ML-C/Ti coating was 1.6 V and offered full protection for BPs. However, the a-C layer and heterogeneous interfaces are prone to dissolution at high potentials. Significantly, to overcome the decline in conductivity induced by corrosion at high potentials, the developed oxide coatings firstly verified the effectiveness of "controllable oxidation". The oxide coatings include $ZrN_xO_y$, $TiN_xO_y$ and AO-C coatings, via oxygen plasma, heat treatment and in situ polarization, respectively. Band bending theory analysis reveals that the oxides with wider band gaps mitigated further oxidation during polarization. Notably, the AO-C layer effectively decreased the adsorption energy of corrosive ions. Combined with the electron tunneling effect through the nanoscale oxide layer, AO-C/Ti coating realized repelling corrosive ions while reserving electron conduction.

Conclusions

Since excessive oxides damage conductivity, determining the optimal content of O to achieve a balance performance is critical.

# sciforum-167950: Decoding Stress Corrosion Cracking in Metallurgical Point-of-View: A Threat to the Structural Integrity of North American Pipeline Infrastructure for Reliable Energy Transportation and Supply in Critical Sectors

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Stress corrosion cracking (SCC) remains one of the most critical degradation mechanisms affecting the structural integrity of North American natural gas pipeline infrastructure. SCC-driven failures threaten the reliability of energy transportation systems and can result in severe safety, environmental, and economic consequences. Despite extensive integrity management programs, SCC continues to challenge conventional monitoring and mitigation strategies because it arises from complex interactions among materials, stresses, and service environments. This study examines SCC from a metallurgical perspective, linking materials science fundamentals with pipeline manufacturing practices and operational conditions to better understand why SCC persists as a dominant failure mechanism. This work synthesizes metallurgical insights with case-based analysis of major pipeline rupture and fire incidents reported in Canada between 2005 and 2024, particularly involving high-pressure, large-diameter transmission pipelines. Published failure investigations, metallurgical examinations, and operational records were reviewed to identify recurring contributors to SCC initiation and propagation. The analysis integrates materials-related factors—including steel grade, microstructure, banding, centerline segregation, non-metallic inclusions, welding-induced residual stresses, and coating–steel interactions—with operational variables such as pressure cycling, thermal fluctuations, cathodic protection imbalance, coating disbondment, soil chemistry, and moisture ingress. The results indicate that SCC develops through the synergistic interaction of tensile stresses, SCC-susceptible microstructures, and aggressive service environments. Metallurgical evidence shows that crack initiation commonly occurs at microstructural heterogeneities and inclusion sites, while operational stresses and environmental exposure accelerate crack coalescence and unstable propagation. Case comparisons further demonstrate that manufacturing quality, coating performance, and cathodic protection management significantly influence crack growth behavior and remaining pipeline life. Overall, SCC should be understood as a system-level degradation mechanism governed by coupled metallurgical, manufacturing, and operational factors rather than a standalone corrosion phenomenon. These findings emphasize the need for microstructure-informed materials selection, improved manufacturing quality control, and predictive integrity management strategies to enhance pipeline reliability and infrastructure resilience.

# sciforum-181846: Effect of Iron (Fe) on the Corrosion Performance of NiCr-based Alloys

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Critical petrochemical industry plant equipment exposed to corrosive chemicals remains susceptible to metal dusting (MD) corrosion, resulting in infrastructure degradation, significant financial losses and huge safety risks. Metal coating is one approach used to inhibit metal dusting. Firstly, this is achieved by adding elements inhibiting the catalytic activity of iron (Fe) and nickel (Ni), such as tin (Sn) or copper (Cu). Secondly, high amounts of chromium (Cr), aluminium (Al) and silicon (Si) can be added to establish a stable protective oxide scale. NiCr-based alloys are well-known multicomponent alloys with a carefully balanced composition that provide the desired properties for various industrial applications. Although these alloys can resist corrosion to a certain extent, MD can still occur under severe conditions, resulting in serious damage to a system in operation. The composition of nickel-based alloys can be tailored to specific operating conditions to improve their reliability. This stems from the fact that alloying the Ni-Cr alloy with transition elements such as molybdenum (Mo), iron and copper can improve the corrosion resistance by promoting the oxide formation process, which contributes to oxide passivity. This study is focused on investigating the effect of adding small amounts of Fe to austenitic Ni-Cr-based alloys in the process of developing a coating material that can form stable protective phases on the surface when reacting with the process environment. The current work reports the results of the initial plan of undertaking low-temperature corrosion simulation tests (electrochemical), with the aim of exposing the coating alloys to metal-dusting environments in the near future. An arc-melting furnace was used to produce the coating alloys, followed by subsequent heat treatment in a tube furnace. Phase and microstructural analyses were conducted using an X-ray diffractometer (XRD) and optical microscopy (OM), respectively. Using an electrochemical potentiostat, corrosion resistance trends at various Fe contents were established.

# sciforum-173292: Electrochemical Corrosion Assessment of Steels with Varying Chromium Content in $NO_2$-containing Phase-Transition Environments in CCUS Infrastructure

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Carbon capture, utilization and storage (CCUS) is a critical technology for reducing atmospheric greenhouse gas emissions by capturing carbon dioxide ($CO_2$) emissions from industrial sources and transporting them for utilization or long-term geological storage. However, the captured $CO_2$ often contains reactive impurities that can accelerate corrosion in transport and storage infrastructure. In particular, water ($H_2O$) and nitrogen dioxide ($NO_2$) readily react to form nitric acid, creating highly aggressive corrosion conditions. While the $CO_2$ is often transported in the supercritical state, pressure reductions at end-use or storage sites can induce phase separation and water condensation. These locations create multi-phase conditions where acid formation and corrosion becomes a concern and emphasizes the need for proper material selection in these areas. This study investigates the initial corrosion behavior of five steels under simulated end-site conditions. Electrochemical corrosion testing in a 0.001 M $HNO_3$ (100 ppmv $NO_2$) solution continuously bubbled with $CO_2$ was performed on X80, 2Cr, 5Cr, P91, and 316L steels using open circuit potential, linear polarization resistance, and potentiodynamic polarization techniques. The chromium (Cr) content of the steels was found to highly influence corrosion resistance with increasing Cr content, reducing the resulting corrosion rate. Overall, X80 had the highest corrosion rate of 0.6 mm/yr, whereas 316L had the lowest corrosion rate of 0.005 mm/yr. Additionally, low Cr steels, particularly 2Cr, displayed unstable corrosion product formation in the linear polarization tests, indicating that small amounts of Cr may be insufficient for proper corrosion protection. The results show that higher-Cr-content steels are better suited for phase-transition regions along CCUS chains. Proper material selection at these critical locations is therefore essential to ensure long-term operational safety and reliability along the CCUS chain.

# sciforum-173541: Electrochemical corrosion measurements in low-conductivity bio-oils: decoupling interfacial film memory from bulk electrolyte aging

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Electrochemical corrosion measurements in viscous, low-conductivity organic media are limited by high cell impedance and parasitic artefacts. This work showcases a robust electrochemical protocol validated in a model bio-oil (MBO, 135 cP) and a more viscous pristine fast pyrolysis bio-oil (P-FPO, 7780 cP) to obtain reliable corrosion kinetic parameters. Established best practices, including open circuit potential (OCP) stabilization, low-amplitude perturbations, and electrochemical impedance spectroscopy (EIS) conductedwithin a charge-transfer-focused frequency window were implemented using a four-electrode cell. Experiments were performed in MBO under three aging systems: Same Solution–Same Electrode (SSSE), Same Solution–Different Electrode (SSDE), and Different Solution–Different Electrode (DSDE). EIS analysis with a physically motivated equivalent circuit resolved the solution resistance ($R_s$), charge transfer resistance ($R_{ct}$), and EIS-derived polarization resistance ($R_p$(EIS)), thereby decoupling the contributions of interfacial film growth and bulk-solution aging to the measured resistances. Uncompensated linear polarization resistance (LPR) slopes initially overestimated $R_p$(LPR) due to the contribution of $R_s$; after ohmic drop (iR) correction using EIS-derived $R_s$, $R_p$(LPR) converged with $R_p$(EIS), enabling rapid yet quantitative corrosion screening. Cross-comparison between MBO and P-FPO systems confirms that a properly wired four-electrode configuration is essential for quantitative corrosion measurements in highly resistive, highly viscous, polymer-rich organic media, particularly when solution resistance is uncertain.

# sciforum-181258: Experimental Assessment of Dielectric Stability in Transformer Oil Using Partial Discharge Energy Signatures

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The assessment of dielectric stability in transformer oil is a critical aspect of condition monitoring in high-voltage equipment. Partial discharges (PDs) are widely recognized as early indicators of insulation degradation, including the progressive degradation of insulating oil; however, their behavior under stable dielectric conditions remains insufficiently characterized in controlled experimental environments.

This work presents an experimental approach to evaluate dielectric stability through the analysis of partial discharge energy signatures derived from electrical measurements. A modular test cell was developed to reproduce controlled PD conditions using spherical electrodes with adjustable inter-electrode distances. This configuration allows the generation of repeatable discharge events under well-controlled electrical conditions representative of early-stage insulation stress. Repeated experiments were conducted under controlled experimental configurations, and current signals were recorded during each discharge event using synchronized measurement equipment. The analysis focuses on physically interpretable indicators, including peak current amplitude and energy-based descriptors computed from the electrical signals.

The results show that, under stable dielectric conditions, these indicators exhibit low dispersion and no significant drift across repeated measurements, indicating stable dielectric behavior and consistent discharge mechanisms.

These findings demonstrate that PD energy signatures can serve as reliable and practical indicators for monitoring dielectric stability and detecting early signs of insulation degradation in transformer oil. The proposed approach provides a relevant basis for condition monitoring strategies in high-voltage insulation systems and is particularly suited for early-stage diagnostics.

# sciforum-180533: Experimental Investigation of Soil Erosion Induced by Leakage in Buried Energy Pipelines

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Against the dual backdrop of energy-structure transformation and the progressive aging of infrastructure, corrosion-induced failures and leakage risks in buried energy pipelines have become increasingly pronounced, posing severe threats to public safety and environmental sustainability. To address the current lack of systematic understanding of the mechanisms by which leaking gas erodes surrounding soil, this study develops an experimental system for gas–soil interaction under medium- to high-pressure buried conditions. Using this system, the damage mechanisms and evolutionary characteristics of soil subjected to gas jets under varying operating conditions are comprehensively investigated. The results indicate that, under high-velocity gas leakage, localized soil particles are progressively detached, leading to the formation of erosion channels extending along the jet direction. These cavities exhibit distinct tensile characteristics, while boundary regions undergo loosening accompanied by secondary structural degradation. As leakage pressure and orifice size increase, the momentum and energy input of the gas jet rise significantly, driving the transition of erosion channels from localized features to fully penetrating structures. However, this evolution process is inherently stochastic and unstable, governed jointly by soil heterogeneity and particle structural properties. Comparative analysis of different soil types reveals that highly compacted clay can develop surface fissures even under relatively low leakage pressures and small orifice diameters. This behavior is primarily attributed to its low permeability, which inhibits rapid gas dissipation and results in localized gas accumulation, causing a sharp increase in pore pressure. This finding deviates from the conventional assumption that clay poses lower leakage hazards, indicating instead that, under specific conditions, clay is more susceptible to localized structural instability and amplified surface responses.

# sciforum-176514: Extending the Service Life of Ageing FPSO and SPM Calm Buoys Under Corrosion Effects: A Case Study on the Hull and Deck Plates

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This research unveils a case study on the structural integrity management of an ageing Floating Production Storage and Offloading (FPSO) unit and Single-Point Mooring (SPM) calm buoy, with a primary focus on the degradation effects of corrosion. Historically, as FPSO and SPM calm buoys exceed their initial design life, the threat of corrosion wastage poses a significant threat to structural reliability, particularly in critical areas such as the hull and deck plates. This paper presents a comprehensive assessment methodology involving in-service survey data, corrosion wastage computations, and structural reassessment to evaluate the remaining thickness of these components, which is a measure of their remaining strength. In conclusion, for the FPSO hull, since 20.12 mm is greater than 19.75 mm, it will serve for the intended 15 years. Thus, the hull is adequate for an additional 15 years in service. Similarly, for the SPM calm buoy hull, since 11.73 mm is greater than 9.725 mm, it will also serve for the intended 15-year extension. Thus, the hull is adequate for the 15-year life extension. Therefore, in each case, the t-end of design life is greater than the t-minimum for life extension. Hence, no steel plate renewal is required on the hulls for the FPSO and SPM calm buoy. These computations were made possible by a computer program code-named HULL LIFE written in the C++ programming language. On the other hand, the computations carried out on the deck plates allowed the recommendation of various mitigation strategies to remedy the corroded deck plate strakes that had fallen below the limiting values. Other strakes or zones that fell within the regime of substantial corrosion were recommended for close monitoring.

# sciforum-173548: From Detection to Action: EMAT-Driven SCC Assessment

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**Introduction.**

Stress corrosion cracking (SCC) is a complex degradation mechanism driven by the presence of mechanical stress, a corrosive environment, and the material's susceptibility. Steel pipelines used for transporting natural gas and oil may be vulnerable, as SCC can initiate and propagate cracks that threaten structural integrity. In advanced stages, the progression of these cracks can reduce the load-carrying capacity of the pipe wall and, under critical conditions, may lead to failure. Consequently, the detection, characterization, and assessment of SCC-related cracking have become components of pipeline integrity management programs.

**Methods.**

Among the available crack detection technologies in the pipeline industry, Electromagnetic Acoustic Transducer (EMAT) in-line inspection tools have gained relevance in recent years. EMAT technology enables the detection, identification, and sizing of linear indications that may be associated with SCC. However, because of the complexity of SCC morphology (crack colonies, crack interaction), accurate classification and sizing can be challenging. Effective characterization requires field verifications that allow the operator to correlate EMAT signal responses with pipeline properties and actual conditions.

**Results.**

In a recent case study, field excavation results confirmed that the EMAT tool detected anomalies associated with SCC. However, subsequent destructive testing highlighted adversities in both sizing and classifying these indications, underscoring the challenges associated with characterizing SCC through an ILI alone and reinforcing the need for complementary data integration and field verifications.

**Conclusion.**

EMAT technology provides capability for detecting and managing anomalies associated with SCC in pipelines, but its effectiveness as part of an SCC integrity management program relies on more than the inspection tool. Threat management requires integrating EMAT results with operational, material, field excavation, destructive testing, and historical data. When EMAT ILI data is combined with material characterization and engineering assessments, operators can make informed integrity decisions and more effectively mitigate the operational risks associated with SCC.

# sciforum-173523: Fungal-Induced Degradation of Polymeric and Composite Materials in Energy Infrastructure

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Non-metallic materials such as polyethylene pipelines and glass fiber-reinforced epoxy composites are widely used in energy infrastructure due to their corrosion resistance, mechanical properties, and cost-effectiveness. However, premature failures in buried and externally exposed components are often attributed to thermal or oxidative aging, while biological deterioration remains largely overlooked. Although bacteria are well known to cause microbiologically influenced corrosion (MIC) in metallic systems, the analogous process in non-metallic materials, referred to as microbiologically influenced degradation (MID), particularly driven by filamentous fungi, has received limited attention. This study aimed to characterize the degradation mechanisms associated with fungal colonization of polymeric and composite materials used in energy distribution systems. Failure analyses were conducted on polyethylene and glass fiber-reinforced epoxy pipelines exhibiting external surface deterioration under field conditions, integrating documented case studies provided by the Corporación para la Investigación de la Corrosión (CIC, Colombia). The methodology included visual inspection, Fourier transform infrared spectroscopy (FTIR), scanning electron microscopy (SEM), thermogravimetric analysis (TGA), differential scanning calorimetry (DSC), and mechanical testing (tensile strength and hardness), along with physicochemical analysis of soils in contact with the pipelines. Fungal isolation from pipe surfaces and adjacent soils was performed to confirm active colonization. SEM analysis revealed surface alterations such as erosion, damage, and wear. FTIR results showed oxidative degradation with the appearance of –OH and C=O functional groups. Mechanical testing indicated variations in tensile strength and hardness, while TGA and DSC analyses showed changes in degradation behavior and the presence of secondary compounds not associated with the original material. Soil conditions favored microbial growth, supporting fungal utilization of polymeric materials as a carbon source. These findings demonstrate that fungal-driven MID can significantly affect the durability of non-metallic infrastructure components and should be incorporated into integrity management and risk assessment strategies.

# sciforum-162566: How can we predict corrosion over millennia?

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Geological disposal of high-level nuclear wastes (HLNW) is planned over hundreds of thousands of years, or even up to several million years. How can we predict the behavior of materials over such durations and, in particular, their corrosion?

We propose a global approach which can be implemented for the geological disposal of high-level nuclear wastes (HLNWs), and present this alongside the main corrosion-related issues. This approach was formalized by Digby's participation at the beginning of the 2000s. Some specificities of the French concept of a geological repository will be underlined: clay underground repository, reversibility concept, HLNWs mainly composed of a glass matrix, a carbon steel overpack, etc.

The main approach is based on “four pillars” which we have developed and which include:

The use of experimental data obtained in laboratories for initial estimation of service lifetimes and corrosion mechanism investigations.Development of modelling (mechanistically based and also stochastic modelling) based on data and mechanisms found in laboratory experiments for robust and reliable prediction.The use of archaeological artefacts to provide data for long-term corrosion rates for the investigation of corrosion mechanisms and for validation of corrosion modelling.The importance of integrated experiments in underground laboratories is underlined to be sure that all the interactions are integrated.

The whole approach is iterative and includes the integration of the evolution of knowledge.

# sciforum-168517: Mechanism of $SO_2$ Effects on the Formation, Evolution, and Corrosion Behavior of $CO_2$ Corrosion Product Films on Carbon Steel

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With the intensification of global warming, controlling $CO_2$ emissions has become a consensus within the international community. CCUS (Carbon Capture, Utilization, and Storage) technology is recognized as one of the critical pathways to achieve the dual carbon goals of 'carbon peaking and carbon neutrality'. Statistics indicate that coal-fired power plants in China contribute over 35% of the total $CO_2$ emissions. The amine-based $CO_2$ capture technology has been widely adopted due to its advantages of high absorption capacity and relatively low regeneration energy consumption. However, flue gas typically contains $SO_2$ in addition to $CO_2$. When $SO_2$ dissolves in amine solutions, it rapidly hydrolyzes to form $HSO_3^-$ and $SO_3^{2-}$. These sulfur-containing species exert a significant influence on the nucleation and growth processes of corrosion product films, triggering accelerated corrosion of carbon steel in equipment such as absorption towers and circulation pipelines. In this study, immersion experiments were conducted to investigate the influence of $SO_2$ on film evolution, as well as the organizational structure of the films at different stages. By employing techniques including weight loss testing, in situ electrochemistry, SEM,EDS, and XPS, this paper clarifies the structural characteristics, evolution, and corrosion behavior of corrosion products under $SO_2$-containing conditions, and elucidates the underlying mechanisms.

# sciforum-176510: Remaining Useful Life Estimation of SPM and FPSO Mooring Chains Under Corrosion Effects

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Floating production, storage and offloading (FPSO) and single-point mooring (SPM) calm buoy mooring chains represent the single point of failure for most offshore floating terminals. However, the recent rise in mooring line failures on FPSO and SPM units, particularly in West Africa, has underscored a critical industry blind spot: the underestimation of corrosion effects in remaining useful life calculations (RUL). Traditionally, remaining strength models assume pristine geometric conditions or apply a uniform corrosion allowance. However, in-service inspections of SPM and FPSO chains frequently reveal accelerated wastage in the splash zone, none of which is adequately captured by linear degradation models. This paper addresses this gap by developing a dedicated RUL estimation methodology centred on corrosion-driven deterioration. We analyzed in situ data from 76 chain samples to characterize corrosion rate distributions specific to the R3 mooring chain grade. The resulting model demonstrates how localized corrosion reduces the net cross-sectional area of the mooring chains' links. By moving from a time-based replacement philosophy to a corrosion-informed RUL prognosis, this work provides operators with the tools to optimize data interpretations, plan for chain replacements and avoid being faced with multiple line failures or domino effects and ultimately system failure while in operation. Over approximately 20 years of service, an operator replaces the top chains of its FPSO mooring chains twice, despite being originally selected for a 20-year service life. This occurs after the first 10 years and, secondly, after the second 10 years due to the excessive corrosion wastage on the FPSO and SPM mooring chains in West Africa. These decisions were reached through detailed mooring chains surveys, measurements and assessments using class society equations. The quantitative results showed that the reductions in the mooring chains' minimum breaking strength (MBS) fall within the range of 10-20%.

# sciforum-150984: SUSCEPTIBILITY TO STRESS-CORROSION CRACKING OF LONG-OPERATED GAS PIPELINE STEEL IN A MODEL SOIL ELECTROLYTE

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Pipe steels after long-term operation under the combined influence of anti-corrosion protection and mechanical stress may demonstrate property degradation, which leads to a deterioration in their service characteristics.

Comparative studies of stress-corrosion cracking of the parent metal of a main gas pipeline with a diameter of 1020 mm made of X60 steel after operation for 50 years, from an undamaged section and a section where a fracture site was detected, were conducted. Investigations were carried out in an NS4 solution under cathodic polarization. Spectrometry, optical metallography, mechanical testing, the slow-rate test method, and scanning electron microscopy methods were used.

The study's results established that the mechanical properties of undamaged and damaged pipes are at the level of the values specified in the pipe certificates. The microstructure is typical for the steel manufactured in the XX century—ferritic–pearlitic with fine ferrite grains (20-25) microns in size. The share of the pearlite component was 50-60% and is approximately the same for both pipes.

The susceptibility to stress-corrosion cracking was estimated by the dimensionless coefficient $K_S$, which was calculated as the ratio of the relative narrowing of the specimens in air to the relative narrowing in the solution.

$K_S$ for the metal of an undamaged pipe at the polarization potential range from -0.75 V to -1.05 V (relative to the saturated silver chloride electrode) in NS4 increases from 1.14 to 1.18. For specimens of damaged pipe, the maximum $K_S$ value of 1.5 is observed at -0.75 V, and it decreases to 1.27 at -1.05 V. It was found that specimens of damaged pipe demonstrated higher maximum stress, lower relative elongation, and relative narrowing at the potential of -1.05 V than specimens from an undamaged pipe. Such patterns may be due to pipe deformation during the accident and the influence of local anodic dissolution.

# sciforum-168537: Synergistic Influence of Deposit Characteristics and Sulfate-Reducing Bacteria on the Corrosion of B10 Copper–Nickel Alloy in Marine Environments

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The co-occurrence of solid deposits and sulfate-reducing bacteria (SRB) poses significant risks of sudden localized failure for copper–nickel alloy infrastructure in complex marine settings. This study systematically investigates the synergistic corrosion mechanisms of B10 alloy beneath four representative deposits with distinct physicochemical properties: insulating silica sand ($SiO_2$), electroconductive magnetite ($Fe_3O_4$), semiconductive cuprous sulfide ($Cu_2S$), and adsorptive kaolin clay. Corrosion kinetics and complex interfacial electrochemical processes were monitored over long-term exposure using open circuit potential (OCP), electrochemical impedance spectroscopy (EIS), and Tafel polarization. Furthermore, the severity of localized attack and denickelification was quantified via 3D laser confocal microscopy, SEM, and EDS analysis. The results demonstrate that the presence of deposits acts as a critical diffusion barrier, entrapping aggressive biogenic sulfides and triggering severe localized acidification and occluded cell effects at the metal/deposit interface. Crucially, conductive deposits such as $Fe_3O_4$ and $Cu_2S$ were found to significantly accelerate cathodic depolarization by increasing the effective cathodic surface area and promoting robust galvanic coupling between the covered and bare metal regions. Meanwhile, kaolin clay exhibited a pronounced "synergistic protection" for SRB colonies by effectively adsorbing released $Cu^{2+}$ ions, thereby mitigating their inherent biocidal effect and fostering robust biofilm development beneath the deposit layer. This research delineates how different deposit types modulate interfacial charge transfer, metabolic byproduct accumulation, and ion migration to accelerate the degradation of Cu-Ni alloys. These findings provide a comprehensive theoretical framework and practical data support for the durability assessment and corrosion mitigation of marine engineering materials under multispecies fouling conditions.

# sciforum-180609: The influence of surface scratch roughness on the hydrogen embrittlement sensitivity of X80 pipeline steel

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As a common surface defect in pipeline steel, surface scratches significantly affect hydrogen embrittlement sensitivity due to their roughness characteristics. It is generally recognized that rougher surface scratches tend to result in higher susceptibility to hydrogen embrittlement. However, in this study, the influence of surface scratch roughness on hydrogen embrittlement sensitivity was systematically investigated in X80 pipeline steel using slow strain rate tensile testing and hydrogen microprint techniques, leading to the discovery of an unexpected phenomenon. Specifically, as the scratch features transitioned from coarse to fine, the hydrogen embrittlement sensitivity first decreased and then increased—a non-monotonic trend that has not been previously reported in the literature. This behavior originates from the synergistic effect between the surface scratch morphology and the residual compressive stress induced by the scratching process, with the two factors exhibiting a competitive relationship. As the grit size of the abrasive paper decreases (i.e., the finer the grit, the smaller the scratch roughness), the scratch dimensions decrease, which helps reduce hydrogen embrittlement sensitivity. At the same time, however, the surface residual compressive stress also diminishes, thereby increasing hydrogen embrittlement sensitivity. The competition between these two effects results in the observed non-monotonic variation in hydrogen embrittlement sensitivity with increasing abrasive paper grit size. Hydrogen-induced cracks almost invariably initiate at the scratch grooves, likely due to localized hydrogen enrichment driven by stress concentration during tensile loading—a mechanism strongly supported by finite element simulation results.

# Session 7. Discovery and Application of Corrosion Inhibitors

# sciforum-181374: Integrated Phytochemical and Electrochemical Screening of Sustainable Corrosion Inhibitors from Biomass and Agro-Industrial Waste for Admiralty Brass

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The development of environmentally benign corrosion inhibitors is critical to reduce the ecological impact of acid cleaning processes in industrial systems. This work presents an integrated approach to the discovery and application of green corrosion inhibitors for admiralty brass (AB), combining molecular-level studies of natural products with the valorization of agro-industrial waste.

In a first stage, latex extracts from *Croton lechleri* (Dragon's blood), a native Amazonian species, were investigated as corrosion inhibitors in 0.5 M HCl. Phytochemical characterization revealed the presence of phenolic compounds and alkaloids, whose heteroatoms and π-electron systems promote adsorption on the metal surface. Electrochemical analyses, including potentiodynamic polarization and electrochemical impedance spectroscopy, demonstrated inhibition efficiencies up to 57% at low concentrations (50 ppm). Surface characterization (SEM, EDS, XPS) confirmed the formation of protective organic films that mitigate dezincification processes.

Building on this mechanistic understanding, a second stage explored low-cost inhibitor sources derived from agro-industrial residues. Extracts from *Musa acuminata* (banana) peels and *Lupinus mutabilis* debittering wastewater were screened using electrochemical methods. While banana extracts exhibited moderate efficiencies (~44%), the alkaloid-rich lupine extract achieved inhibition efficiencies above 80%, highlighting the effectiveness of waste-derived systems.

Finally, a techno-economic pre-feasibility analysis supports the scalability of the lupine-based inhibitor. This work bridges fundamental insights and applied screening, advancing sustainable corrosion protection strategies and promoting circular economy approaches based on Latin American biomass resources.

# sciforum-177114: The selection of corrosion inhibitors for Mg alloys via the evaluation of mechanical integrity

**Di Mei**

Zhengzhou Uinversity

Magnesium and its alloys possess unique advantages in the fields of lightweight structural materials and biodegradable medical metallic materials. However, the chemically active nature of magnesium exacerbates localized corrosion of magnesium alloys. This issue significantly restricts the widespread application of magnesium and its alloys.

Corrosion inhibitor technology is an effective means to improve the corrosion resistance of metallic materials, achieved by introducing a small amount of compounds into the corrosive environment to markedly reduce the corrosion rate of materials. After years of research, a number of highly efficient magnesium alloy corrosion inhibitors have been reported. However, most studies primarily focus on the effect of inhibitors on the corrosion rate of magnesium alloys, failing to fully evaluate magnesium alloy corrosion inhibitors in combination with their actual service requirements.

For magnesium alloys, whether used as lightweight structural materials or biodegradable medical metallic materials, they need to maintain sufficient mechanical strength to bear corresponding loads during service. Studies have shown that the corrosion rate of magnesium alloys in different media environments cannot directly reflect their ability to maintain the original mechanical strength in corresponding environments, and the latter is directly related to the service reliability of magnesium alloys in such environments. Our recent research found that relying solely on corrosion rate measurement makes it difficult to objectively evaluate the actual effectiveness of magnesium alloy corrosion inhibitors.

This presentation will report the relevant research results of our team on magnesium alloy corrosion inhibitors. The most core highlight lies in taking the mechanical integrity and corrosion fatigue behavior of magnesium alloys under the action of corrosion inhibitors as reference indicators for the screening of corrosion inhibitors, which is of great significance for expanding the practical application of corrosion inhibitors.

# sciforum-181173: Computational Experiments for Designing High-Performance Oxadiazole Corrosion Inhibitors

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Organic corrosion inhibitors protect steel against degradation by forming chemisorbed molecular films, with inhibition efficiency governed by the interplay between electronic structure and adsorption behaviour. This work employs density functional theory (DFT)-based computational screening [1] to design and evaluate a novel series of oxadiazole-based inhibitors for Fe surfaces, establishing a rigorous structure–property–performance relationship. Using the recently reported high-performance inhibitor 2-(5-methylthiophen-2-yl)-5-(pyridin-**3**-yl)-1,3,4-oxadiazole (MTPO-3) as a structural benchmark [2], a systematic library of isomers was generated through systematic rational modification of heteroatom positions and ring connectivity. DFT calculations identified 2-(5-methylthiophen-2-yl)-5-(pyridin-**2**-yl)- 1,3,4- oxadiazole (MTPO-2) as the most stable isomer, exhibiting a higher HOMO energy, lower LUMO energy, and a narrower HOMO–LUMO gap—collectively indicative of superior electronic reactivity and enhanced electron-donor capacity toward Fe. Spin-polarised DFT calculations were subsequently employed to evaluate the adsorption energetics of MTPO-2 and MTPO-3 on Fe(100) and Fe(110) surfaces. The computed adsorption energy of MTPO-3 on Fe(110) shows close agreement with published values [2], validating the reliability of the surface adsorption model. MTPO-2 consistently exhibited stronger adsorption across both surface facets, corroborating its superior electronic profile. These results demonstrate that DFT-guided isomer engineering is a powerful and systematic strategy for the rational design of high-performance oxadiazole corrosion inhibitors. Full computational details and mechanistic insights will be presented at the conference.

# sciforum-168492: Corrosion Inhibition of Steel in Acidic Medium Using Artemisia Plant Extract: A Natural and Eco-Friendly Method

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Corrosion in acidic environments represents a major challenge in many industrial sectors, particularly in pipelines, chemical processing units, and metallic equipment exposed to aggressive conditions. Metal degradation caused by corrosion results in economic losses, safety concerns, and reduced service life of industrial components. Therefore, environmentally friendly corrosion inhibitors are increasingly required. This study evaluates the effectiveness of Artemisia plant extract as a natural corrosion inhibitor for metals in a 1 M hydrochloric acid solution.

The Artemisia extract was prepared using water as a solvent and applied to metal samples immersed in the acidic medium. Gravimetric weight loss measurements were used to investigate the effects of inhibitor concentration, immersion time, and temperature on corrosion rate and inhibition efficiency. The results show that increasing inhibitor concentration significantly reduces corrosion rate while improving inhibition efficiency, indicating effective adsorption of extract components onto the metal surface.

Conversely, increasing temperature and acid molarity decreases inhibition efficiency and increases corrosion rate due to reduced stability of the protective film. Electrochemical techniques including Electrochemical Impedance Spectroscopy and Potentiodynamic Polarization will be employed to validate the gravimetric results. The inhibition mechanism is attributed to the formation of an adsorbed protective layer on the metal surface. These findings highlight the potential of plant-based inhibitors for sustainable corrosion protection in acidic industrial environments.

# sciforum-173558: Electrochemical insights on silicate-based corrosion inhibition for pipeline materials

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In many industries, using corrosion inhibitors to protect piping systems remains a highly cost-effective strategy. While the primary goal is to reduce corrosion to acceptable levels, there is a growing demand for sustainable, "green" alternatives. Sodium silicate (SS) has emerged as a promising candidate, offering a non-toxic, eco-friendly, and readily available inorganic solution.

This study evaluates SS as a corrosion inhibitor for steel, copper, and zinc in flowing saltwater. To simulate the conditions of an open recirculating cooling water system, a rotating-cylinder electrode setup was used, with surface flow speeds ranging from 0.5 to 1 m/s. A comprehensive electrochemical evaluation was performed using potentiodynamic scans (PDS), electrochemical impedance spectroscopy (EIS), and Mott-Schottky (M-S) analysis.

The results from PDS and EIS demonstrated that SS drastically lowers corrosion rates by forming protective layers. Inhibition efficiencies reached up to 99% for steel, 97% for copper, and 88% for zinc. EIS and M-S curves provided additional insights into film structure, revealing a direct link between improved film properties and overall film stability. However, the interaction with zinc proved complex; at low concentrations, a competition emerged between the formation of the protective silicate layer and the development of non-protective insoluble species.

The study also highlighted a distinct difference in flow speed interaction for each metal. Combined EIS and M-S analysis revealed an interesting interplay between SS concentration and flow velocity. The resistance to flow-induced degradation varied significantly with substrate material and inhibitor bulk concentration. Ultimately, these findings confirm that sodium silicate is a highly effective and versatile green alternative for protecting multi-metal piping systems under dynamic flow conditions.

# Session 8. AI and ML Tools and Digital Twins for Corrosion Prediction

# sciforum-181142: Detection of Pitting Corrosion in Stainless Steel Sheet Pile Walls using Deep Learning

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Stainless steel sheet pile walls are increasingly adopted in agricultural drainage channels as a corrosion-resistant alternative to conventional steel sheet piles. However, their high passive-film stability means that measurable thickness reduction does not occur within approximately ten years of installation, rendering conventional ultrasonic thickness measurement ineffective for early-stage condition assessment. This study proposes a deep learning-based automated detection system for pitting corrosion on stainless steel sheet pile surfaces using visible images acquired with a standard smartphone camera.

Two martensitic and ferritic stainless steel grades, SUS410 (Pitting Index: 11) and SUS430 (Pitting Index: 16), were sampled from an agricultural drainage channel in Niigata Prefecture, Japan, after five years of exposure in a brackish water environment with chloride ion concentrations of approximately 120 mg/L. Pixel-level annotation was performed on cropped regions of approximately 60 mm × 270 mm, and the U-Net semantic segmentation model was adopted as the detection model. Bayesian hyperparameter optimization using Optuna with the Tree-structured Parzen Estimator was applied across 100 independent trials to ensure robust performance evaluation. Data augmentation using vertical flip and blur operations was incorporated to improve generalization on the limited dataset.

The deep learning approach achieved F1-scores of 0.831 (SUS410) and 0.808 (SUS430), substantially outperforming the conventional binary thresholding baseline (F1-scores: 0.407 and 0.329, respectively). Data augmentation contributed improvements of approximately 1.2–2.8 percentage points. The results also confirmed the superior pitting resistance of SUS430, which exhibited markedly lower pit density and area ratio relative to SUS410. The proposed method enables non-destructive, quantitative assessment of early-stage pitting corrosion using readily available imaging equipment, offering a practical and cost-effective tool for infrastructure maintenance and long-term durability evaluation of agricultural water management facilities.

# sciforum-168528: Evaluation of the applicability of dose–response functions incorporating time of wetness: Analysis of outdoor exposure test data for carbon steel and zinc across multiple countries

**Shin Ohara**

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A dose–response function (DRF) incorporating time of wetness (*TOW*) as an input parameter was proposed by Ohara *et al.* (2024) based on outdoor exposure test data for carbon steel and zinc in Japan. The environmental input factors of the DRF include chloride deposition ($S_d$), time of wetness, and temperature. Corrosion rate maps were also generated by combining the proposed DRF with spatial distributions of these environmental factors. By expressing the $S_d$ term in the DRF as an exponential function, the estimated corrosion rate maps successfully reproduced the decreasing trend with increasing distance from the coastline, indicating that the DRF is applicable to the evaluation of atmospheric corrosivity in Japan. In this study, the *TOW*-based dose–response functions proposed by Ohara *et al.* (2024) were examined with respect to their applicability to outdoor exposure test data for carbon steel and zinc obtained in multiple countries, including data from the ISOCORRAG program (Knotkova *et al.*, 2010). Based on environmental data available in the ISOCORRAG database, the corrosion rates of carbon steel and zinc were estimated using *TOW* and $S_d$ as input parameters. For data with $S_d$ exceeding 200 mg $m^{-2}$ $day^{-1}$, primarily from coastal sites in Sweden, Norway and France, the corrosion rates were significantly overestimated. In contrast, for Sd below 200 mg $m^{-2}$ $day^{-1}$, the estimated corrosion rates showed better agreement with the measured values. These results indicate that the proposed *TOW*-based dose–response functions still face challenges in evaluating atmospheric corrosivity across multiple countries, particularly in regions with substantially higher chloride deposition.

# sciforum-180539: Machine learning-based prediction of carbonation-induced reinforcement corrosion initiation risk in reinforced concrete under Kinshasa climate conditions

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Natural carbonation of reinforced concrete is a major mechanism of steel depassivation and may lead to corrosion initiation once the carbonation front reaches the reinforcement, making it a critical durability issue for structures exposed to tropical urban climates. This study developed a machine learning framework to predict carbonation-induced reinforcement corrosion initiation risk under climate conditions representative of Kinshasa. The workflow combined a RILEM natural carbonation database containing 1,744 records, including 863 mix-level observations and 6,879 time-series measurements, with Kinshasa climate descriptors based on temperature, relative humidity, and an atmospheric $CO_2$ proxy. After filtering, 847 observations contained usable numerical climate information for model training. Four models were evaluated, namely Ridge regression, Random Forest, Gradient Boosting, and a median-based dummy baseline. Gradient Boosting achieved the best performance, with grouped cross-validation by reference yielding an RMSE of 0.0737 and an $R^2$ of 0.6101, while the reference-based holdout test produced an RMSE of 0.0668, an MAE of 0.0510, and an $R^2$ of 0.6488. For a 25 mm concrete cover, the median estimated time for the carbonation front to reach the reinforcement level was 18.30 years under a typical dry Kinshasa climate scenario and 16.05 years under an annual mean Kinshasa climate scenario; at 30 years, the proportion of profiles reaching corrosion initiation was 70.72% and 74.26%, respectively. These results show that an open-data, machine learning-based framework can provide a first quantitative estimate of carbonation-driven corrosion initiation risk in Kinshasa, while also highlighting the need for future local validation and improved representation of the most humid exposure conditions.

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