

Electrochemical Corrosion Solutions



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INTRODUCTION - ELECTROCHEMICAL CORROSION

According to a recent IMPACT study by AMPP International, the global cost of corrosion expenses is estimated to be US \$2.5 trillion in 2023. By using the available corrosion control practices, it is estimated that savings of 15 to 35% of the total cost of corrosion could be realized (Between US\$375 and \$875 billion annually) on a global scale each year if proper measures are executed. These costs typically do not include individual safety or environmental consequences. Utilities, particularly water and sewer systems, suffer the biggest economic impact, with motorized vehicles and transportation coming in a close second.

As per Wikipedia "Corrosion is a natural process, which converts a refined metal to a more chemically stable form, such as its oxide, hydroxide, or sulfide." It is the gradual destruction of materials (usually metals) by chemical and/or electrochemical reaction with their environment. It occurs generally when two dissimilar metals are sharing the same electrolytic medium such as sea water or moisture. The amount of corrosion depends upon the potential difference between the two metals, the conductivity of solution between them, the electrical connection between the two and their electro-negativity.

Typically, different parts of the same metal made dissimilar (by treatment) or a metal and its oxide (sufficiently dissimilar) create a corrosion process. An "anodic" area, such as iron oxide, is eaten away creating more rust, while an electric current is created, leaving the metal at the anodic area and entering it at the cathodic area, where no corrosion occurs. An inhibitor coating protecting the metal, if perfect, increases electrical resistance and retards the corrosion process. However, at any imperfection in the coating, a deep pitting may be generally caused by concentrating the electrolytic effects.

For the research and development of such novel cost-effective inhibitors, each year, more than millions of dollars are spent to study the fundamental principles governing such complex real-life corrosion processes and thereby, to reduce their impact on a global scale. The American Society for Testing and Materials recently published their newest edition of Manual (MNL20-2ND-EB) that serves as a great source book for procedures, equipment, and standards used in electrochemical corrosion testing). Overall, 20+ ASTM standards are now readily available to conduct regulatory based testing of electrochemical corrosion in different fields.

At BASi Research Products, we provide instruments and accessories to conduct regulatory based corrosion testing on real life samples. We also provide highly advanced research solution packages in corrosion market to well-known scientists, analysts, researchers, consultants, and engineers across the globe. Our overall product portfolio mainly include advanced, portable and blue-tooth controlled potentiostats / galvanostats that are hand-held and can be taken out in the field. We also provide a wide variety of corrosion cell set-ups, probes, sample holders and other accessories that can be customized according to user's areas of research. Our state-of-the art multichannel platforms allows users with high throughput requirements to conduct multiple corrosion analysis on 64 samples at the same time. Each of our systems are equipped with highly advanced corrosion techniques and methods. Furthermore, we also provide customized tools for corrosion education, corrosion education labs, learning modules and more.

EMSTAT 4S HIGH RESOLUTION SERIES

The EmStat 4S HR Series are USB- powered portable potentiostats / galvanostats with EIS option available for a wide variety of corrosion measurements, regulatory testing, and even basic level corrosion research.

FEATURES & BENEFITS:

- > Portable & Hand-held
- > On-field analysis possible
- > Wide range of corrosion protocols
- > Optional EIS with fit and simulation
- > Multi-channel version available

SELECTED TECHNIQUES WITH PSTRACE:

- > Polarization Resistance Studies
 - > Linear, Cyclic, Galvanostatic
- > Automated Tafel Plot Analysis
- > Corrosion Rate Measurement
- > Zero Resistance Amperometry
- > Open Circuit Potential
- > Constant Current / Potential
- > Basic EIS Study upto 200 KHz



- > Current Range:
 - > HR (± 100 nA - ± 100 mA)
- > Max. Current:
 - > HR (± 200 mA)
- > Optional Expandability
 - > EIS: (10 μ Hz - 200 kHz)

PALMSENS4 SERIES

The PalmSens4 is a fully loaded, expandable, and hand-held potentiostat / galvanostat with EIS option that is fully customizable as per the user requirements for an advanced level corrosion testing and research with expandability options such as temperature/ pH monitoring, RDE control, IR-compensation, bi-potentiostat control and more.

FEATURES & BENEFITS:

- > Can be used in field and bench-top set-up
- > Bluetooth, USB & battery connections
- > External triggers for thermal controlled analysis
- > Accurate 1 MHz EIS with fit & simulation
- > Excellent low current resolution
- > High compliance voltage for thick films

APPLICATIONS:

- > EIS based inhibitor efficiency analysis of thick films
- > Critical Pitting Analysis with thermal control
- > Polarization Resistance Studies
 - > Linear, Cyclic, Galvanostatic
- > Corrosion Rate Measurement with Tafel Plot simulation
- > Zero Resistance Amperometry
- > Open Circuit Potential
- > Step-wise dissolution at constant current / potential



- > Current Range: (± 100 pA - ± 10 mA)
- > Max. Current: (± 30 mA)
- > Compliance Voltage: (± 10 V)
- > Optional Expandability
 - > EIS: (10 μ Hz - 1 MHz)
 - > IR-compensation
 - > pH / Temperature Monitoring
 - > RDE control

1L ASTM GRADE CORROSION CELL

The IP-U-1L-CCWJ is a fully equipped, vertically mounted, and ASTM G59-97 grade jacketed type corrosion cell set-up that can be used with any Potentiostat / Galvanostat / Impedance Analyzer in the world. This set-up heavily suits the petroleum, automobile and other such industrial level corrosion labs that have a high through-put requirement for a very direct ASTM grade corrosion measurement for quality control, new inhibitor or coatings test, and plant safety.

PART NUMBER:

> **IP-U-1L-CCWJ** ASTM grade 1L Corrosion Cell Kit

STANDARD PACKAGE:

- > Reference Electrode
- > Counter Electrode
- > Jacketed 1L Multi-port vessel
- > Lugging Capillary
- > Purge and vent option
- > Three types of Sample Holders with sample coupon
- > All accessories included

FEATURES:

- > Available in 500 mL or 1000 mL volumes
- > Option for pH / temperature monitoring
- > Thermal control with Jacketed vessel
- > Sample holders:
 - > Button type for circular coupons
 - > Clip type for flat coupons
 - > Threaded type for cylindrical coupons

APPLICATIONS:

- > ASTM G59-97 Potentiodynamic corrosion test
- > Critical pitting test and analysis
- > Evan's curve analysis
- > Diffusion based research for corrosion mechanism
- > EIS based coating inhibitor / paint resistance analysis
- > Electrochemical Noise / ZRA Analysis
- > Step-wise dissolution measurement
- > Galvanic cycling analysis



NEW AND IMPROVED RDE-2 CELL STAND FOR LIQUID INHIBITOR STUDY

The BASi RDE-2 is a rotator system for both fixed rotation rate and hydrodynamic modulation rotating disk electrochemical experiments. Rotation rates from 50 to 10,000 RPM are available with better than 1% accuracy. BASi's new C1018 carbon steel inserts perfectly screws onto the redesigned RDE-2 electrode body holder (PCTFE) for an easy and low-cost option to conduct corrosion research studies related to liquid inhibitor efficiency for corrosion resistance.

PART NUMBER:

- > **EF-1100** RDE-2 Rotating Disk Electrode Cell Stand

STANDARD PACKAGE:

- > Cell stand with gas purge capabilities
- > Glassy carbon working electrode
- > Ag/AgCl reference electrodes (+ storage vial)
- > Platinum wire auxiliary electrode
- > PK-4 working electrode polishing kit

FEATURES:

- > Compatible with BASi stationary voltammetry electrodes
- > Standard addition port for adding inhibitors
- > Easy and rapid exchange of disposable SS inserts
- > Low-noise electrode contact
- > Excellent rotation speed accuracy

APPLICATIONS:

- > Corrosion mechanism research
- > Kinetics evaluation for liquid inhibitors
- > Film forming amines studies
- > Step-wise dissolution analysis
- > EIS based film resistance studies in pipelines



LIQUID INHIBITOR ANALYSIS PACKAGE



COATING EVALUATION TEST CELL

This cell allows you to isolate a part of a metal sheet and perform an electrochemical characterization. With this setup, different parts of the same metal sheet can be conveniently evaluated. The diameter of the testing area is 42 mm. The maximum thickness of the sample is 3 mm.

PART NUMBER:

> **PALM-IS-CETC** Coating Evaluation Test Corrosion Cell Kit

FEATURES:

- > Coating inhibitor test on large samples
- > Easy plug-n-play assembly
- > Electrodes, parts and accessory included

CORROSION APPLICATIONS:

- > Large sample area tests
- > Coating inhibitor efficiency analysis
- > Paint resistance tests
- > Alloy polishing quality control
- > Alternative quality test to ASTM B117 "spray test"



ELECTROCHEMICAL CORROSION CELL KIT - FLAT CELL

This set-up heavily suits the corrosion scientists, analysts and researchers that have a high through-put requirement for conducting analysis on coupons with square, rectangular, circular, or any other shapes. Rather than a dedicated sample holder, the sample coupon can be easily mounted or replaced onto the cell in less than 10 seconds.

PART NUMBER:

> **IP-U-CCG-FS250** 250 mL Flat Corrosion Cell Kit

FEATURES:

- > Fully jacketed and acrylic option available
- > Samples: Circular, rectangular, square
- > Purge option available
- > Plug-n-play configuration

APPLICATIONS:

- > Critical pitting analysis 3 deg. C to 90 deg. C
- > High through-put lab environment
- > Analysis on samples of different sizes / shapes
- > Alkaline or aqueous environments
- > Sample holder / lugging capillary not required



ELECTROCHEMICAL H-CELL FOR HYDROGEN PERMEATION STUDIES

This is a Devnathan-Stachurski type H-Cell specifically designed to conduct hydrogen permeation test on circular coupons with options for purge, thermal control and lugging capillary.

PART NUMBERS:

- > **IP-HC50** Standard H-Cell Kit
- > **MF-2024** Working Electrode Holder (Alligator clip)

FEATURES:

- > Optional designs for volume (100 - 1000 mL)
- > Thermal control possible
- > Floating ground multichannel available
- > Plug-n-play configuration

APPLICATIONS:

- > Hydrogen Permeation Measurements
- > New Membrane Research
- > Hydrogen / Oxygen Evolution Studies
- > Water-splitting analysis



WELDED JOINT TEST CELL

The IP-U-COR-WD is a fully equipped, vertically mounted corrosion cell set-up for direct in-situ measurements on corrosion samples such as polished welded joints, cylindrical pipes and other square, circular, or rectangular coupons.

PART NUMBER:

- > **IP-U-COR-WD** In-situ Corrosion Test Cell for Non-flat surfaces

FEATURES:

- > Direct in-situ measurements
- > Specially designed for 1 mm diameter spot type analysis
- > All types of curved or non-flat surfaces
- > Leakage proof design

APPLICATIONS:

- > Welded joint tests
- > Cylindrical coupons or any other with non-flat surfaces
- > EC Noise based analysis on very small surfaces



EIS PLUS CORROSION PACKAGE

This EIS Plus Corrosion Package includes everything you need for conducting advanced level corrosion research in your lab. The PalmSens4-EIS is the included instrument which is a highly advanced USB / battery-powered Potentiostat / Galvanostat with a built-in Electrochemical Impedance Spectroscopy (EIS) analyzer. Together with our PStace software, a well-written corrosion handbook, and a fully equipped corrosion cell kit, it makes an excellent package for our researchers, scientists and analysts to conduct a wide variety of corrosion studies using methods listed (but not limited to) below.

CORROSION ANALYSIS METHODS:

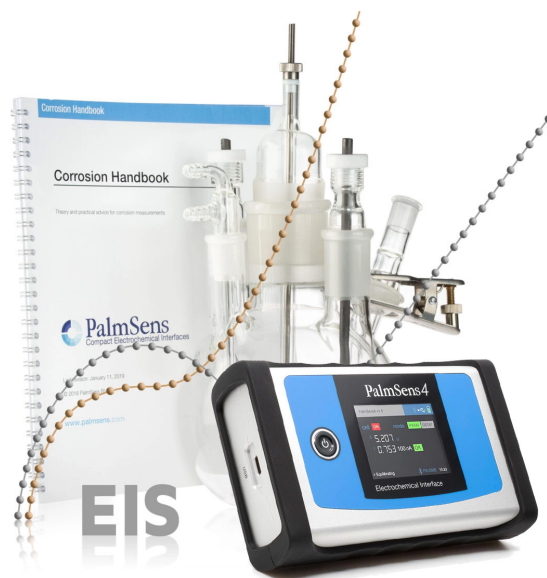
- > Linear polarization method to quantify
 - > Corrosion rates
 - > Corrosion current / potential
- > Apply accurate current for inducing corrosion
- > Step-wise dissolution analysis
- > Deposit inhibitor films
- > Critical pitting analysis
- > EIS Methods to extract parameters such as
 - > Coating resistance
 - > Polarization resistance
 - > Pore resistance
 - > Coating capacitance
 - > Water uptake of a coating
 - > The time to failure (TTF) Estimation
 - > Corrosion kinetics

SELECTED TECHNIQUES WITH PSTRACE:

- > Open Circuit Potential
- > Chronopotentiometry / Chrono amperometry
- > EIS with Fit & Simulation (10 μ Hz - 1 MHz)
 - > Potential / Time scan
 - > Fixed potential
- > Polarization Techniques
 - > Potentiostatic
 - > Galvanostatic
 - > Linear
 - > Cyclic

KIT INCLUDES:

- > 1000 mL Fully Equipped Corrosion Cell with Electrodes
- > Corrosion Manual with Instructions
- > PalmSens4 with EIS option
- > Rugged carrying case
- > PStace Software - Corrosion Techniques Included
- > All additional accessories



BASIC EIS CORROSION PACKAGE

This package is designed to provide a highly effective yet cost-effective solution set to modern day corrosion researchers, scientists and engineers. The EmStat 4S High Resolution potentiostat / galvanostat with EIS is packaged with 1000 mL corrosion cell kit, corrosion manual and other accessories to measure / monitor corrosion rates on newly developed inhibitors, coatings and films.

CORROSION ANALYSIS METHODS:

- > Polarization Techniques
 - > Potentiostatic
 - > Galvanostatic
 - > Linear
 - > Cyclic
- > Open Circuit Potential
- > Zero Resistance Amperometry
- > Constant Current / Potential
- > EIS with Fit & Simulation (10 μ Hz - 200 KHz)

KIT INCLUDES:

- > 1000 mL Corrosion Cell with Electrodes
- > Corrosion Manual with Instructions
- > EmStat 4S HR with EIS (10 μ Hz - 200 KHz)
- > PSTrace Software - Corrosion Techniques Included



STANDARD CORROSION ANALYSIS PACKAGE

This package is designed to provide a cost-effective solution set to early-stage corrosion researchers, analysts, scientists and engineers. The non-EIS version of EmStat 4S High Resolution potentiostat / galvanostat is packaged with 1000 mL corrosion cell kit, corrosion manual and other accessories to conduct basic corrosion measurements such as LPR, OCP and ZRA analysis.

CORROSION ANALYSIS METHODS:

- > Polarization Techniques
 - > Potentiostatic
 - > Galvanostatic
 - > Linear
 - > Cyclic
- > Open Circuit Potential
- > Zero Resistance Amperometry
- > Constant Current / Potential Measurements

KIT INCLUDES:

- > 1000 mL Corrosion Cell with Electrodes
- > Corrosion Manual with Instructions
- > EmStat 4S HR
- > PSTrace Software - Corrosion Techniques Included



MORE INFORMATION ONLINE

PRICES:

www.BASinc.com/products/all

TERMS OF SALE:

www.BASinc.com/products/terms

LIMITED WARRANTY:

BASi instruments manufactured by the company carry a one-year limited warranty.

Full details at: www.BASinc.com/products/terms

EXTENDED WARRANTY AND MAINTENANCE PROTECTION PLAN:

A Maintenance Protection Plan is available for a complete electrochemical or voltammetric analyzer, or individual electroanalytical instruments including potentiostats, cells, controllers, etc. This extends the one year warranty that normally applies to these instruments. The cost of this plan is most advantageous when purchased with a new instrument. Instruments which are out of warranty must be inspected by BASi, for at least the cost of the estimate fee, prior to being registered for an extended warranty.

TO PLACE AN ORDER:

AR_Orders@BASinc.com or call 765.463.4527 ext. 5828



CORPORATE HEADQUARTERS

2701 Kent Avenue

West Lafayette, IN 47906

800.845.4246 | 765.463.4527

www.BASinc.com

