Corrosion And Conservation Of Cultural Heritage Metallic Artefacts 22 The Role Of Standards In Conservation Methods For Metals In Cultural Heritage European Federation Of Corrosion Efc Series

Modelling and electrochemical simulation of corrosion confirms that the decay rate of iron shipwrecks is cathodically controlled by the flux of dissolved oxygen. The rate falls logarithmically with increasing water depth with splash zone corrosion rates at zero water depth. The interaction of corroding iron with the marine biota is complex and symbiotic. Corrosion rates are interdependent on the salinity and temperature of the surrounding seawater which determines the amount of dissolved oxygen. Monitoring the corrosion potentials and pH of wreck materials provides a very sensitive indicator of changes in environment brought about through natural or human intervention.

‘Artistic/intentional’ patina is a surface layer intentionally produced by an artist or a specialized professional on a metallic artwork with aesthetic or practical purposes. From the science of surfaces point of view the ‘artistic’ patina could be considered as an interface between the metallic substrate and the external environment and therefore affecting, depending on its physical and chemical peculiarities, the corrosion process. In order to understand how the ‘artistic’ patina behaves inside the exposure environment, an experimental activity was carried out: the study of the data collected with the application of

different analytical techniques contributed to a more pertinent knowledge of the characteristics of metallic works of art which, in turn, leads to a restoration process respecting their real nature.

This chapter gives general information on the production of sol-gel coatings with alkoxysilanes. Some examples of their application on outdoor bronze artefacts are reported. The protective effects of 3-mercapto-trimethoxysilyl-propane (Prop-SH) hydroalcoholic solution on polished and patinated bronzes were studied. Electrochemical tests, performed in acidic artificial rain (AAR, pH 3.1) and in 5% NaCl solution for 168h, were checked in 45d AAR Salt Cabinet and in 30d ASTM B117 Test on bronze statues. The treatment with Prop-SH showed high efficiency towards the corrosion both in AAR and in 5% NaCl.

Current research into the removal of soluble chloride corrosion drivers from archaeological iron by deoxygenated aqueous alkaline treatments is described and assessed, along with suggestions for future work. The problems of how to determine treatment success are discussed, along with the impact of treatment unknowns, such as chloride form and location within iron objects, on the assessment techniques. Post-treatment residual chloride is shown to be the best measure of treatment effectiveness and methods for assessing this are described. A real-time study of oxygenated and deoxygenated treatment mechanisms and corrosion product transformations using micro X-ray diffraction is reported.

This chapter introduces the techniques used when investigating corrosion layers formed on cultural heritage artefacts. Various multiscale analysis methods, from macroscopic to nanoscopic scales, are presented. Information on the morphology, the elementary composition and the crystalline structure that each method allows for determining the constituents of the

corrosion layers is examined, as well as their limits in terms of set-up, spatial and detection resolution. This chapter discusses the characteristics of the scientific tools that can be used to understand corrosion phenomena, by taking into account the major parameters responsible for alteration mechanisms.

Metallographic investigations may be an essential component in the search for authenticity and fabrication technology. Assessing how an artefact is made may involve metallographic examination, usually entailing the removal of a small sample from the object concerned. Examples of the use of metallography are discussed with reference to copper alloys, high-tin bronzes, Chinese bronze mirrors, copper plaques, iron and steels, and plated or coated metals, such as depletion gilded surfaces or those covered with gold foil or other metals. The different types of features which metallography can reveal concerning ancient metallic structures are briefly discussed with several colour photomicrographs which illustrate the features described in this chapter. The importance of metallography as one component of the scientific tools to aid in the determination of authenticity of ancient metallic artefacts is stressed, and an example given of old electrotypes from the Victoria and Albert Museum. Important literature references are provided to direct the reader to more detailed studies on the subject.

The sixteen essays in this volume reflect a wide range of research concerning methods for metals conservation, particularly in respect to ancient and historic objects. The variety of issues discussed includes considerations in the cleaning of ancient bronze vessels; the processes involved in bronze casting, finishing, patination, and corrosion; studies of manufacturing techniques of gold objects in ancient African and medieval European

metalworking; techniques of mercury gilding in the 18th century; an investigation of patina in the classification of bronze surfaces from land and lake environments; an examination of bronze objects from the Benin Kingdom, Nigeria; the history of restoration of the Marcus Aurelius monument in Rome; the corrosion of iron in architecture; and applications of radiographic tomography to the study of metal objects.

This chapter reviews the applicability and specific uses of corrosion inhibitors in metal conservation practice. Corrosion inhibitors are one of the different methods used by conservation-restoration professionals to preserve metallic cultural heritage. In the first part, specific requirements and needs for corrosion inhibitors in conservation treatments are reviewed, as well as the different methods for the assessment of their efficiency. The second part of the chapter reviews the different inhibitors used by type of metals: copper and its alloys, iron and its alloys, and other metals (including silver, lead and zinc), from traditional ones to state-of-the-art treatments.

This chapter describes the recent advances in corrosion protection afforded by the use of ultra-thin organic films such as polymer films and self-assembled monolayers. Emphasis is given to the metal surface modification by self-assembled monolayers of carboxylic acids due to their properties and ability to protect metallic artefacts.

Europe has a rich industrial cultural heritage, including technical objects and industrial sites. This chapter discusses basic types of metallic objects of industrial cultural heritage including their material properties and surface treatments from the point of view of corrosion behaviour in specific atmospheric conditions to which they are exposed. The general principles of conservation ethics and problems of these types of cultural heritage are mentioned. Two case

studies of evaluation of condition of typical industrial cultural objects are given.
This practical guide provides artists, conservators, curators, and other heritage professionals with tools for understanding, evaluating, and approaching the care and treatment of modern metals. The proliferation of new metals—such as stainless steels, aluminum alloys, and metallic coatings—in modern and contemporary art and architecture has made the need for professionals who can address their conservation more critical than ever. This volume seeks to bridge the gap between the vast technical literature on metals and the pressing needs of conservators, curators, and other heritage professionals without a metallurgy background. It offers practical information in a simple and direct way, enabling curators, conservators, and artists alike to understand and evaluate the objects under their care. This invaluable reference reframes information formerly found only in specialized technical and industrial publications for the context of cultural heritage conservation. As the first book to address the properties, testing, and maintenance issues of the hundreds of metals and alloys available since the beginning of the twentieth century, it is destined to become an essential resource for conservators, artists, fabricators, curators, collectors, and anyone working with modern metals.
Pigments, corrosion products, and minerals are usually considered separately, either as painting materials or as the deterioration products of metals, even though they are often the same compounds. This 190-year review of the literature on copper and its alloys integrates that information across a broad spectrum of interests that are all too frequently compartmentalized. The author discusses the various environmental conditions to which copper alloy objects may be exposed-including burial, outdoor, and indoor museum environments-and the methods used to conserve them. The book also includes information on

ancient and historical technologies, the nature of patina as it pertains to copper and bronze, and the use of copper corrosion materials as pigments. Chapters are organized primarily by chemical corrosion products and include topics such as early technologies, copper chlorides and bronze disease, the chemistry and history of turquoise, Egyptian blue and other synthetic copper silicates, the organic salts of copper in bronze corrosion, and aspects of bronze patinas. A detailed survey of conservation treatments for bronze objects is also provided. Four appendixes cover copper and bronze chemistry, replication experiments for early pigment recipes, a list of copper minerals and corrosion products, and X-ray diffraction studies.

Electrochemical impedance spectroscopy (EIS) is a powerful tool in developing the most appropriate methodology for ensuring long-lasting artefact preservation. EIS consists in the measurement of amplitude and phase of the surface impedance of coated metallic objects at different frequencies in order to highlight either the protective effectiveness of a coating or the stability of a corrosion product layer grown onto the metallic surface. Two in-situ EIS measuring campaigns are described together with the description of the portable instrument and the measuring probes specifically designed and developed for cultural heritage applications.

This chapter attempts to address monitoring problems from a wider point of view than is usual in the cultural heritage field. It discusses the issues connected to variations of space and time in the measured quantities. Some differently structured systems which can be employed in designing a monitoring infrastructure are discussed and a case study is reported to illustrate the practical application of general guidelines.

Relationships between conservation and corrosion scientists are assessed and similarities,

differences and synergies identified. Corrosion control as a preservation option for heritage metals is advocated as being cost-effective and pragmatic. This will require generation of data to develop predictive conservation and estimation of object lifespan as a function of their intrinsic and extrinsic variables. Methods for quantitative determination of corrosion rates of chloride infested heritage iron and techniques for scaling to heritage value are discussed. The iron hull of the ss Great Britain and an AHRC/EPSRC Heritage Science Research Programme at Cardiff University are used to illustrate the rationale behind using corrosion control in heritage.

This chapter deals with an overview of the application of plasma technologies, an innovative environmentally friendly class of processes for the surface modification of materials, for cleaning and protection of metallic artefacts. Examples of plasma enhanced chemical vapour deposition (PECVD) of organosilicon precursors are described and appear particularly promising for the corrosion protection of the different metallic substrates such as iron-based alloys, copper and silver-based alloys of archaeological and historical-artistic interest.

From 2nd to 5th October 2012 an International Congress on Science and Technology for the conservation of Cultural Heritage was held in Santiago de Compostela, Spain, organized by the Universidade of Santiago de Compostela on behalf of TechnoHeritage Network. The congress was attended by some 160 participants from 10 countries, which presented a tot

This chapter focuses primarily on the common environmental aspects of atmospheric metal corrosion. The effects of climate and pollution on corrosion

are reviewed across various timescales, from damage over millennia to the present situation, including short descriptions of the indoor environment and recent developments in international standardisation. The chapter concludes with two sections on future trends in air pollution and climate change.

The third International congress of Science and Technology for the Conservation of Cultural Heritage, TechnoHeritage 2017, was held in Cadiz, from 21 to 24 May 2017, under the umbrella of the TechnoHeritage network. TechnoHeritage is an initiative funded by the Spanish Ministry of Economy and Competitivity dedicated to the creation of a network which integrates CSIC and University groups, private companies and end users such as foundations, museums or institutions. The network's purpose is to foster the creation of transdisciplinary (and not only multidisciplinary) initiatives focused on the study of all assets, movable or immovable, that make up Cultural Heritage. A high-quality scientific programme was prepared, which includes new emerging topics on Cultural Heritage (1) Nanomaterials and other Products for Conservation, (2) New Technologies for Analysis, Protection and Conservation, (3) 20th Century Cultural Heritage, (4) Significance of Cultural Heritage. Policies for Conservation, (5) Deterioration of Cultural Heritage, (6) Biodeterioration: Fundamentals, Present and Future Perspectives and (7) Underwater Cultural Heritage. A special session

"Biodeterioration: Fundamentals, present and future perspectives, a session in honour of Prof. Cesáreo Sáiz Jiménez" took place. Our intention was to recognise the work of Prof. Sáiz Jiménez, who recently retired, and its impact on the Cultural Heritage conservation community, which he has helped to promote through numerous activities including, in 2011, the creation of the TechnoHeritage network. This volume publishes a total of eighty-three contributions which reflect the state of the art investigations on different aspects of cultural heritage conservation.

Oxygen is a key factor in corrosion and decay of artefacts from our cultural heritage. The measurement of oxygen concentrations and quantification of oxygen consumption is therefore extremely useful in both corrosion and conservation science. This chapter focuses on two aspects of oxygen monitoring: first, measurement of oxygen consumption of cultural heritage artefacts to evaluate their corrosion rate and the efficiency of conservation treatments, and second, measurement of oxygen concentration in the burial environment to evaluate the preservation conditions and understand the formation of different corrosion products in situ. The chapter includes a short description of equipment for oxygen measurement, and gives some examples of its use for monitoring purposes.

Understanding the long-term corrosion mechanisms of iron in an anoxic environment is essential in the field of the preservation of archaeological heritage artefacts and nuclear waste management. Corrosion mechanisms have been assessed by examining nails 400 years old from the archaeological site of Glinet. This chapter provides an overview of the characterisation of the entire corrosion system environment/samples through coupled multiscale analytical tools. The environment is anoxic, calco-carbonated and water-saturated. Three corrosion patterns composed of ferrous carbonates (siderite and chukanovite) and magnetite have been identified. Depending on the connection between the phases and their location, the electronic properties of the corrosion layers have been established. The electrochemical behaviour of the corrosion system shows that water reduction at the metallic interface is negligible. Furthermore, the electron consumption sites are mainly localised on the external part and the precipitation sites on the internal part of the corrosion layer. The corrosion rate is estimated to be less than 2?m/year and a corrosion mechanism is proposed based on a decoupling of the anodic and cathodic sites and on the existence of a nanometric corrosion layer at the metallic interface.

Corrosion and conservation of cultural heritage metallic artefacts1. Introduction: conservation versus laboratory investigation in the preservation of metallic

heritage artefactsElsevier Inc. ChaptersCorrosion and conservation of cultural heritage metallic artefacts22. The role of standards in conservation methods for metals in cultural heritageElsevier Inc. Chapters

This chapter deals with the description of suitable and innovative solutions devoted to preserve metallic artefacts in their original contexts, underwater cultural heritage sites of archaeological and historical interest, as well as with the analysis of the degradation processes of ferrous and non-ferrous artefacts induced by contact with an aggressive environment such as sea water. The chapter also provides an overview of the most common conservation strategies applied to recovered artefacts.

The basic principles of corrosion and electrochemistry are briefly summarised to indicate the capabilities of electrochemical techniques in diagnostic and conservation of heritage metals. The basic elements of each electrochemical measurement – cell, electrolyte, instrumentation – are schematically illustrated in the specific application to cultural heritage. The different measurement techniques are reviewed, divided into three groups: (1) potential measurements; (2) DC techniques; (3) AC techniques. The aims and fields of application are discussed, reporting several examples of specific applications in the field of cultural heritage.

The conservation of metallic archaeological and historic artefacts is a major challenge whether they are ancient bronzes or relics of our more recent industrial past. Based on the work of Working Party 21 Corrosion of Archaeological and Historical Artefacts within the European Federation of Corrosion (EFC), this important book summarises key recent research on analytical techniques, understanding corrosion processes and preventing the corrosion of cultural heritage metallic artefacts. After an introductory part on some of the key issues in this area, part two reviews the range of analytical techniques for measuring and analysing corrosion processes, including time resolved spectroelectrochemistry, voltammetry and laser induced breakdown spectroscopy. Part three reviews different types of corrosion processes for a range of artefacts, whilst part four discusses on-site monitoring techniques. The final part of the book summaries a range of conservation techniques and strategies to conserve cultural heritage metallic artefacts. Corrosion and conservation of cultural heritage metallic artefacts is an important reference for all those involved in archaeology and conservation, including governments, museums as well as those undertaking research in archaeology and corrosion science. Summarises key research on analytical techniques for measuring and analysing corrosion processes Provides detailed understanding of corrosion processes and corrosion prevention Discusses on-site monitoring techniques

This book mostly contains contributions by the invited lecturers at the 7th International Conference on Non-Destructive Testing and Micro-Analysis for the Diagnostics and Conservation of the Cultural and Environmental Heritage. The contributors have all been chosen for their individual reputations and the quality of their research, but also because they represent a field deemed highly important. Hence, this book give balanced coverage of the

areas that are most relevant in non-destructive testing and micro-analysis in the realm of cultural heritage. The analysis methods provide the clinical composition of cultural artifacts to elucidate their provenance, the rate of alteration as a result of exposure to the environment and the effectiveness of conservation and restoration strategies. The techniques are partially or fully non-destructive, are portable, or allow study of different parts of a heterogeneous work of art.

This chapter reviews and summarises the results of experiments using a new technique known as ‘subcritical’ for the stabilisation of archaeological iron. Five case studies are presented that illustrate the capacity of this technique to rapidly remove entrapped chloride ions from unstable metal with minimal observable changes to the objects’ integrity. This overview focuses on the effectiveness of this treatment from a conservation and preservation perspective. The benefits and current limitations of the technique are identified, as well as important areas where there is a need for further research.

This chapter discusses the importance of using standards in conservation methodology and practice for cultural heritage (CH) metals. The past general trend in the field is the use of metal industry standards. The chapter surveys the relevant scientific publications, and concludes that conservation researchers use a variety of these standards adopted by different organisations. As a result, it can be difficult to compare scientific data for CH metal studies carried out by different laboratories. The chapter discusses the necessity to draft new standards for metals specific for CH by examining how three independent researchers had different findings when testing the same coating. The role of CEN/TC 346 ‘Conservation of Cultural Heritage’ is also discussed.

This chapter discusses the application of the voltammetry of microparticles, a solid-state electrochemical technique, to the field of corrosion of archaeological metal. Identification of metals and alloys, identification, mapping and layer-by-layer analysis of corrosion products on metal surfaces using this technique are described. Applications include quantification of components of alloys and corrosion layers, and evaluation of metal conservation and the kinetics of long-term corrosion processes. Specific applications in archaeometry, conservation and restoration include authentication and dating.

- A comprehensive journey through the history of iron - Aims to become a main reference text on this subject - Of interest to enthusiasts of anthropology, iron-age and art This book will be of interest to all who seek to further their understanding of iron artefacts: their corrosion, conservation, and pigments based on iron compounds, which mankind has used for millennia. The authors take the reader through some of the latest observations on the occurrence and role of compounds of iron - from the hot water undersea vents where the presence of iron pyrites is thought to be vital to the emergence of life on Earth, to the discovery of jarosite on the surface of Mars, possibly indicating the presence of water; from the pyrophoric surprises one can have when dealing with iron artefacts taken from beneath the sea to the use of a blue oxide of iron as a pigment in mediaeval wall paintings; from rusticles on the Titanic to the analysis of coloring matter on the Turin shroud. The great variety of iron compounds is examined (from the simple oxides to the exotic green rusts, from Prussian blue to yellow jarosites), the corrosion of iron in different environments is discussed and a critical review of the many attempts to conserve iron is presented. This volume will serve as a useful textbook on the subject for many years.

Understanding long term corrosion processes is critical in many areas, including archaeology and conservation. This important book reviews key themes such as the processes underlying corrosion over long periods, how corrosion rates can be measured and materials conserved. After an overview of the study and conservation of metal archaeological artefacts, a group of chapters reviews long term corrosion in metals such as steel, iron and bronze. Other chapters review the impact of environmental factors on corrosion rates. The book also considers instrumental techniques for measuring corrosion such as electrochemistry and scanning electron microscopy, as well as ways of modelling corrosion processes. There is also coverage of the effectiveness of corrosion inhibitors. With its distinguished editors and contributors, Corrosion of metallic heritage artefacts improves our understanding of long term corrosion and its effects. It provides a valuable reference for those involved in archaeology and conservation, as well as those dealing with the long term storage of nuclear and other waste. Reviews long term corrosion in metals such as steel, iron and bronze Considers instumental techniques such as electrochemistry for measuring corrosion

This chapter discusses the evaluation of metal conservation treatments using a specialized electrochemical cell. The cell can be deployed in a synchrotron beam line to make in-situ, time-lapse measurements on heritage metal alloys undergoing processes based on electrochemical treatments/measurements. We focus on two specific projects: (1) the evaluation of currently used stabilization processes for cupreous objects recovered from marine environments, and (2) the development and testing of a coating to protect lead objects which is stable, reversible (i.e. easy to apply and to remove), protective against corrosion and aesthetically justified.

"Conservation of Cultural Heritage covers the methods and practices needed for future

museum professionals who will be working in various capacities with museum collections and artefacts. It also assists current professionals in understanding the complex decision making processes that faces conservators on a daily basis. Covering a broad range of topics that are key to sound conservation in the museum, this volume is an important tool for students and professional alike in ensuring that best practice is followed in the preservation of important collections"--

Conservation Science is a rather innovative application of instrumental analysis with steadily increasing importance. Although the first attempts for preserving material from the cultural heritage on a scientific basis are found in the 19th century pioneer chemistry years, only the use of sophisticated physicochemical techniques results in effective identification and deterioration studies of monuments and objects, and in reliable intervention procedures. This volume allows to gain solid knowledge and improved skills on the ways separation schemes and diagnostic methodologies are applied in the safeguarding and authentication of tangible works of art; as well as on the modes of implementing novel safeguarding practices built on well-established principles – such as the use of laser in the decontamination of objects. All techniques are covered at a state-of-the-art level; while selected applications permit addressing major groups of materials and artefacts. Conservation Science is nowadays taught at master's level in all developed countries, and museum laboratories increasingly adopt scientific approaches in their restoration initiatives. The book is intended as a valuable tool for students and professionals active in these frames. In addition, it provides an indispensable manual for participants in the specialized intensive courses, which are systematically offered by the authors under the auspices of the relevant European network.

The use of silver in ancient civilisations of Mesopotamia, Egypt, Ionia, Greece, Rome and China is presented. Principles of silver corrosion in different environments containing humidity, oxygen, carbonates, sulphur, chlorides, peroxides, ozone and UV, and the morphology of the corrosion layers are described. Cleaning, anti-tarnishing and protection methods are explained. Inhibitor hexadecanethiol (HDT) and a composite coating of Paraloid B-72 containing 2% nano-alumina pigment are tested on silver specimens with tarnished and corroded surfaces and found to be protective when exposed in sulphides and chloride environments in the laboratory, satisfying aesthetic and reversibility criteria.

In the present chapter laser-induced breakdown spectroscopy (LIBS) is introduced as a powerful spectrochemical analytical technique that can be exploited to characterize corroded artifacts. Scientific and technological aspects of LIBS are briefly presented. LIBS does not need sample preparation, it is nondestructive and it can be used for in-situ measurements. Examples of LIBS applications that can help archaeologists in conservation and restoration of metallic artifacts are given. We demonstrated the use of LIBS in analysis of corroded metal threads, depth profiling of copper-based decorative artefact, analysis of corroded Punic coins, and LIBS and XRF analysis of Roman silver denarii.