DEVELOPMENTS
IN
CORROSION SCIENCE

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This file presents some historical landmarks and timeline of discoveries related to the understanding and management of corrosion and also development in corrosion science.

Although the future successes will still relate to improvements in materials and their performance, it can be expected that the main progress in corrosion prevention will be associated with the development of better information- processing strategies and the production of more efficient monitoring tools in support of corrosion control programs.

TABLE I.4 Landmarks of Discoveries Related to the Understanding and Management of Corrosion

Date	Landmark	Source
1675	Mechanical origin of corrosiveness and corrodibility	Boyle
1763	Bimetallic corrosion	HMS Alarm report
1788	Water becomes alkaline during corrosion of iron	Austin
1791	Copper-iron electrolytic galvanic coupling	Galvani
1819	Insight into electrochemical nature of corrosion	Thenard
1824	Cathodic protection of Cu by Zn or Fe	Sir Humphrey Davy
1830	Microstructural aspect of corrosion (Zn)	De la Rive
1834–1840	Relations between chemical action and generation of electric currents	Faraday
1836	Passivity of iron	Faraday, Schoenbein
1904	Hydrogen overvoltage as a function of current	Tafel
1905	Carbonic and other acids are not essential for the corrosion of iron	Dunstan, Jowett, Goulding, Tilden
1907	Oxygen action as cathodic stimulator	Walker, Cederholm
1908–1910	Compilation of corrosion rates in different media	Heyn, Bauer
1910	Inhibitive paint	Cushman, Gardner
1913	Study of high-temperature oxidation kinetics of tungsten	Langmuir
1916	Differential aeration currents	Aston
1920–1923	Season-cracking of brass = intergranular corrosion	Moore, Beckinsale
1923	High-temperature formation of oxides	Pilling, Bedworth
1924	Galvanic corrosion	Whitman, Russell
1930–1931	Subscaling of "internal corrosion"	Smith
1931–1939	Quantitative electrochemical nature of corrosion	Evans
1938	Anodic and cathodic inhibitors	Chyzewski, Evans
1938	E-pH thermodynamic diagrams	Pourbaix
1950	Autocatalytic nature of pitting	Uhlig
1956	Tafel extrapolation for measurement of kinetic parameters	Stern, Geary
1968	Electrochemical noise signature of corrosion	Iverson
1970	Study of corrosion processes with electrochemical impedance spectroscopy (EIS)	Epelboin

TABLE 1.1 Timeline of Developments in Corrosion Science

L.J. Thénard	1819	Enunciated electrochemical nature of corrosion
Sir H. Davy	1829	Principle of cathodic protection
A. de la Rive	1830	Established best quality of zinc for galvanic batteries
M. Faraday	1834–1840	Established relations between chemical action and generation of electric currents based on what were later called "Faraday's laws"
S. Arrhenius	1901	Postulated the formation of microcells
W.R. Whitney	1903	
A.S. Cushman	1907	Confirmed the theory of microcells
W. Walker	1907	Established the role of oxygen in corrosion as a cathodic simulation
A. Cederholm		
L. Bent, W. Tilden	1908	
E. Heyn and O. Bauer	1908	Corrosion studies of iron and steel, both alone and in contact with other metals, leading to the concept that iron in contact with a nobler metal increased corrosion rate, while its contact with a base metal resulted in partial or complete protection
R. Corey		
T. Finnegan	1939	Investigated attack of iron
M. de Kay Thompson	1940	
A. Thiel	1928	Investigated the attack of iron by dilute alkali with liberation of hydrogen
Luckmann		
W. Whitman, R. Russell	1924	
U. Evans	1928	Observed increased corrosion rate when a small anode is connected to a large cathode
G.V. Akimov	1935	

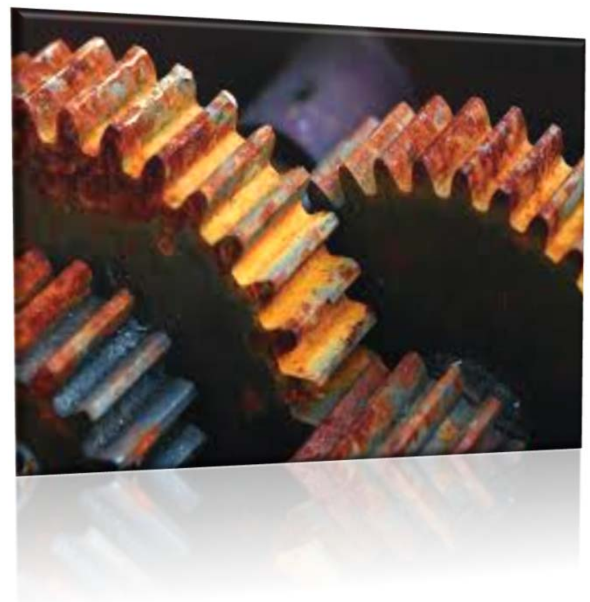

TABLE 1.2 Development of Some Corrosion-Related Phenomena

J.S. MacArthur	1887	Process of cyanide dissolution of gold (gold is not soluble in hot acids)
P.F. Thompson	1947	Dissolution of gold in dilute cyanide solutions recognized as an electrochemical process
	Concept of Passivity	
J. Keir	1790	Observed that iron in concentrated nitric acid altered its properties
C.F. Schönbein	1799–1868	Suggested the state of iron in concentrated nitric acid as passivity
W. Müller (K. Konopicky, W. Machu)	1927	Postulated the mathematical basis of the mechanism of anodic passivation
G.D. Bengough (J.M. Stuart, A.R. Lee, F. Wormwell)	1927	Systematic and carefully controlled experimental work on passivity
	Role of Oxygen	
Marianini	1830	Indicated the electric currents were due to variations in oxygen concentration
Adie	1845	
Warburg	1889	
V.A. Kistiakowsky	1908	
	~1900	Hydrogen peroxide detected during the corrosion of metals
	~1905	The view that acids were required for corrosion to occur dispelled by observation of rusting of iron in water and oxygen
Aston	1916	Role of local differences in oxygen concentration in the process of rusting of iron
McKay	1922	Currents due to a single metal of varying concentrations of metal ion

(continued)

TABLE 1.2 (*Continued*)

U.R. Evans	1923	Differential aerations and their role in metallic corrosion
Evans and co-workers	1931–1934	Electric currents due to corrosion of metal in salt solutions were measured and a quantitative electrochemical basis of corrosion was propounded. The oxygen-rich region becomes cathodic and the metal is protected, while the lower oxygen region, being anodic, is attacked
		Inhibitors
Roman civilization	–	Protection of iron by bitumen, tar, extracts of glue, gelatin, and bran were used to inhibit corrosion of iron in acid
Marangoni, Stefanelli	1872	Distinction between inhibitive paints and mechanically excluding paints made, based on laboratory and field tests Development of paints containing zinc dust
Friend	1920	Colloidal solution of ferric hydroxide acts as an oxygen carrier, passing between ferrous and ferric states
Forrest, Roetheli, Brown	1930	Protective property of coating varied and depended on the rate of supply of oxygen to the surface
Herzog	1936	Postulated that iron, on long exposure to water, becomes covered by magnetite overlaid by ferric hydroxide. Magnetite layer acts as cathode and ferric hydroxide is converted to hydrated magnetite. Hydrated magnetite may lose water and reinforce the preexisting magnetite or absorb oxygen from air to give ferric hydroxide.
Chyzewski	1938	Classified inhibitors as cathodic and anodic inhibitors
V.S. Sastri	1988	Classification of corrosion inhibition mechanisms as interface inhibition, intraphase inhibition, interphase inhibition, and precipitation coating (*Corrosion '88*, paper no. 155)
V.S. Sastri	1990	Modern classification of inhibitors as hard, soft, and borderline inhibitors (30)
K. Jüttner, W.J. Lorenz, F. Mansfeld	1993	*Reviews on corrosion inhibitor science and technology*, 1993
V.S. Sastri, J.R. Perumareddi, M. Elboujdaini	1994	Novel theoretical method of selection of inhibitors (*Corrosion*, **50**, 432, 1994)

TABLE 1.2 (*Continued*)

V.S. Sastri, J.R. Perumareddi, M. Elboujdaini	2005	Sastri equation relating percent inhibition to the fractional electronic charge on the donor atom in the inhibitor (6)
V.S. Sastri, J.R. Perumareddi, M. Elboujdaini, M. Lashgari	2008	Application of ligand field theory in corrosion inhibition (*Corrosion*, **64**, 283, 2008)
V.S. Sastri, J.R. Perumareddi, M. Elboujdaini	2008	Photochemical corrosion inhibition (*Corrosion*, **64**, 657, 2008)
	Microbiological Corrosion	
R.H. Gaines	1910	Sulfate-reducing bacteria in soils produce H_2S and cause corrosion
	Role of thermodynamics	
–	–	Corrosion of metals obeys the laws of thermodynamics; was recognized in the early development of corrosion science
M. Pourbaix	1940	Pourbaix diagrams involving pH and potential give regions of corrosion, immunity, and passivity
	Kinetics	
Evans, Hoar	1932	Quantitative correlation of corrosion rates with measured electrochemical reaction rates
F. Habashi	1965	Validity of single kinetic law irrespective of the metal, composition of the aqueous phase, and evolution of hydrogen when no insoluble products, scales, or films are formed

TABLE 1.3 Numbers of Corrosion Science Publications

Theme	1907	1950	2000	2007
Corrosion	35	922	10,985	15,903
Corrosion and protection	3	122	1,162	1,578
Corrosion inhibition	0	19	367	416

TABLE 1.4 Beginning Journal Years for Corrosion Developments

Title	Year
Corrosion	1945
Corrosion Science	1961
British Corrosion Journal	1965
Werkstoffe und Korrosion	1950
Corrosion Prevention and Control	1954
Anti-corrosion Methods and Materials	1962
Materials Performance	1962

TABLE 1.5 Organizations at Forefront of Corrosion Science Starting Year

American Society for Testing Materials (ASTM)	1898
American Society of Metals (ASM)	1913
Corrosion Division of the Electrochemical Society	1942
National Association of Corrosion Engineers	1943
Comité international de thermodynamique et cinétique électrochimique (CITCE)	1949
International Society of Electrochemistry (ISE)	1971
International Corrosion Council	1961
The Corrosion Group of the Society of Chemical Industry	1951
Belgium Centre for Corrosion Study (CEBELCOR)	1951
Commission of Electrochemistry	1952
National Corrosion Centre (Australia)	
Australian Corrosion Association	~1980
Chinese Society of Corrosion and Protection	~1980
National Association of Corrosion Engineers (in Canada)	–

This presentation was developed by Kamran Khodaparasti.

References:
Vedula. S. Sastri, Green Corrosion inhibitors-Theory and Practice, 2011
Pierre R. Roberge, Handbook of Corrosion Engineering, 1999