

Stereochemistry of Coordination Compounds. From Alfred Werner to the 21st Century

Alex von Zelewsky*

Abstract: As a contribution to the scientific symposium, November 22nd, 2013, commemorating the Nobel Prize awarded to Alfred Werner in 1913, a presentation of the development of stereochemistry of coordination compounds during the past 120 years was given. Stereochemistry was fundamental to Werner's theory of coordination compounds. After Werner's death in 1919, stereochemistry in this field did not progress much further for almost 20 years, but then developed continuously. It was realized that stereochemical features of elements showing coordination numbers larger than four are responsible for an almost unlimited number of stereochemical possibilities, thus opening a molecular world of new structures. In the beginning of the 21st century, interest in the field rose again considerably, mainly due to the potential of stereoselective catalysis, and the self-assembly of supramolecular structures. An end of these developments is not in sight. Here an abbreviated version of the lecture is given. A PowerPoint® file, or a video of the presentation, can be downloaded.^[1–5]

Keywords: Chirality · Coordination compounds · Stereochemistry · Stereoselectivity · Werner, Alfred

Introduction

20 years after the publication of his fundamental formulation of the coordination concept, Alfred Werner was awarded the Nobel Prize in Chemistry in 1913. Werner's views of the molecular structure of compounds of metallic elements proved to be correct for a vast number of compounds and it is still the basis for contemporary research and development in many branches of chemistry. Werner based his theory to a large part on considerations about the numbers and types of isomers of compounds of transition metals. It is basically a theory exploring the various possibilities to arrange atoms in three-dimensional space and this is nothing else but the subject of stereochemistry.

The coordination theory is one of the unbreakable hard rocks of science that will

probably never be succeeded by a better concept. To commemorate the centenary of the Nobel Prize of Alfred Werner, the Department of Chemistry at the University of Zürich organized a symposium on several aspects of coordination chemistry. I had the privilege to review the development of stereochemistry of coordination compounds from Alfred Werner to the present. Here, only a short excerpt of the presentation in the symposium is given. A first specialized textbook on 'Stereochemistry of Coordination Compounds'^[6] by the present author appeared one hundred years after the basic publication by Alfred Werner.^[7] It is fully referenced and covers also the historical development in some detail. A second, more specialized book by Amouri and Grussile, was published recently.^[8] It covers the topical subject of chirality in transition metal chemistry in great detail. Chirality was already of central interest to Alfred Werner. His experimental proof in metal compounds was the main reason for the Nobel committee to award the Prize in 1913. In addition to these two books, a number of reviews have been published in recent years,^[9–12] proving the revived interest in the subject.

The Development of Stereochemistry of Coordination Compounds since Alfred Werner

After the proposition of the tetrahedral carbon atom by van't Hoff and Le Bel in 1874, stereochemistry of organic com-

pounds developed rapidly during the last quarter of the 19th century, as recognized by the second Nobel Prize in Chemistry awarded to Emil Fischer in 1902. In the beginning of this period, inorganic chemistry was still dominated by the view of the Danish chemist Sophus Mads Jørgensen, who was an excellent experimental chemist. Jørgensen adhered strictly to the chain theory of Blomstrand, one of the leading chemists of the 19th century. The seminal publication of a 27-year-old chemist, Alfred Werner, appeared in 1893.^[13] Werner introduced the octahedron as a coordination center. Most notably, in the same publication, he attributed to Pt(II) compounds the coordination number four in a square planar arrangement. The tetrahedral arrangement for coordination number four, however, was so deeply burned into the mind of chemists during the last quarter of the 19th century that it needed a highly independent mind to dare to propose the planar structure for metal compounds. In 1899 the first mention of the possibility of "asymmetry" in an octahedral complex followed^[14] and in 1911 the proof of the existence of two separable enantiomers in a cobalt compound was presented.^[15] It was shown in 1914, finally, that optical activity is not necessarily associated with the presence of carbon.^[16] A carbon-free complex, Co(hexol), comprising a central cobalt atom, surrounded by four bidentate ligands that are themselves cobalt-amine complexes, was separated into its enantiomers. After 1914, the activity of the Zürich group ceased rapidly, due to Werner's severe ill-

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Stereochemistry Of Coordination Compounds

Geoffrey A. Lawrance



Stereochemistry Of Coordination Compounds:

Stereochemistry of Coordination Compounds Alexander von Zelewsky, 1996-06-03 This well illustrated and well referenced book provides a systematic introduction to the modern aspects of the topographical stereochemistry of coordination compounds which are made up of metal ions surrounded by other non metal atoms ions and molecules

Complex Formation and Stereochemistry of Coordination Compounds, 1996 The Stereochemistry of Coordination Compounds James Edward George, 1965 **Low-Frequency Vibrations of Inorganic and Coordination**

Compounds John R. Ferraro, 2012-12-06 During the course of far infrared investigations of inorganic and coordination compounds at Argonne National Laboratory in the years 1962-1966 it became apparent that no suitable book existed which correlated and discussed the important vibrations occurring in this region for these molecules Early in 1967 the initial steps were taken to write such a book Then in 1968 an excellent text by Professor David M Adams entitled Metal Ligand and Related Vibrations was published At this point serious consideration was given to discontinuing work on this book However upon examination of Adams book it became clear that the references covered only the period to 1966 This field of research is accelerating so tremendously and the period 1966-1969 has seen so many new studies that upon reconsideration it was decided to continue writing this text The references in this book particularly in the last several chapters include many papers published in 1969 However the proliferation of the far infrared literature has made it impossible to present all the published material that has any bearing on the subject Many titles do not pertain primarily to the far infrared region as such and some of this research has been omitted for this reason Organometallic compounds have been neglected since the author feels that adequate reviews of that subject are available Other studies may be missing simply because owing to space limitations only the more important researches could be considered Of course importance may in this case reflect the author's interest and prejudices **Coordination Chemistry** Fred Basolo, Ronald C. Johnson, 1964 *Coordination Chemistry* Stanley

Kirschner, 2013-11-11 **Chirality in Transition Metal Chemistry** Hani Amouri, Michel Gruselle, 2008-11-20 Chirality in Transition Metal Chemistry is an essential introduction to this increasingly important field for students and researchers in inorganic chemistry Emphasising applications and real world examples the book begins with an overview of chirality with a discussion of absolute configurations and system descriptors physical properties of enantiomers and principles of resolution and preparation of enantiomers The subsequent chapters deal with the specifics of chirality as it applies to transition metals Some reviews of Chirality in Transition Metal Chemistry useful to students taking an advanced undergraduate course and particularly to postgraduates and academics undertaking research in the areas of chiral inorganic supramolecular complexes and materials Chemistry World August 2009 the book offers an extremely exciting new addition to the study of inorganic chemistry and should be compulsory reading for students entering their final year of undergraduate studies or starting a Ph D in structural inorganic chemistry Applied Organometallic Chemistry Volume 23 Issue 5 May 2009 In

conclusion the book gives a wonderful overview of the topic It is helpful for anyone entering the field through systematic and detailed introduction of basic information It was time to publish a new and topical text book covering the important aspect of coordination chemistry It builds bridges between Inorganic organic and supramolecular chemistry I can recommend the book to everybody who is interested in the chemistry of chiral coordination compounds Angew chem Volume 48 Issue 18 April 2009 About the Series Chirality in Transition Metal Chemistry is the latest addition to the Wiley Inorganic Chemistry Advanced Textbook series This series reflects the pivotal role of modern inorganic and physical chemistry in a whole range of emerging areas such as materials chemistry green chemistry and bioinorganic chemistry as well as providing a solid grounding in established areas such as solid state chemistry coordination chemistry main group chemistry and physical inorganic chemistry

Introduction to Coordination Chemistry Paul V. Bernhardt, Geoffrey A. Lawrance, 2025-03-24

INTRODUCTION TO COORDINATION CHEMISTRY An accessible introduction to one of the primary fields of study in Inorganic Chemistry revised to incorporate contemporary topics and applications Written in a highly readable descriptive and accessible style Introduction to Coordination Chemistry examines and explains the interaction between metals and molecules that bind as ligands and the consequences of this assembly process The book describes the chemical and physical properties and behavior of these complex assemblies and their applications The contents of this book tell a story taking the reader from fundamentals including metal ions ligands metal ligand bonding and structure to key concepts such as stability synthesis and mechanisms properties and characterization Subsequent chapters address applications involving metals in biology medicine and industrial chemistry Written by two highly qualified academics this newly revised Second Edition of Introduction to Coordination Chemistry has been thoroughly updated to include full color images throughout as well as now including Information on instrument based experimental methods to reflect the increasing use of sophisticated commercially available instruments in laboratory teaching An expansion of the chapter Metals in Biology showing key developments in the vast field of metalloproteins and metalloenzymes An updated description of polymetallic compounds and new discussions of metal containing nanomolecules pertinent to advancements in nanotechnology An expanded discussion of organometallic compounds and catalysts and updating of Concept Keys to summarize key topics and further reading at the end of each chapter Introduction to Coordination Chemistry is an ideal textbook resource for undergraduate inorganic chemistry students in their second or third year or at the intermediate level who have completed a general introductory chemistry course and are moving to a first specialist course in coordination chemistry

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Introduction to Coordination Chemistry Geoffrey A. Lawrance, 2013-03-15 At the heart of coordination

chemistry lies the coordinate bond in its simplest sense arising from donation of a pair of electrons from a donor atom to an empty orbital on a central metalloid or metal. Metals overwhelmingly exist as their cations but these are rarely met naked; they are clothed in an array of other atoms, molecules or ions that involve coordinate covalent bonds; hence the name coordination compounds. These metal ion complexes are ubiquitous in nature and are central to an array of natural and synthetic reactions. Written in a highly readable, descriptive and accessible style, *Introduction to Coordination Chemistry* describes properties of coordination compounds such as colour, magnetism and reactivity as well as the logic in their assembly and nomenclature. It is illustrated with many examples of the importance of coordination chemistry in real life and includes extensive references and a bibliography. *Introduction to Coordination Chemistry* is a comprehensive and insightful discussion of one of the primary fields of study in Inorganic Chemistry for both undergraduate and non-specialist readers.

Studies on the Stereochemistry of Some Coordination Compounds Trevor Robert Gilson, King's College London.
Department of Chemistry, 1964

Whispering the Techniques of Language: An Emotional Journey through **Stereochemistry Of Coordination Compounds**

In a digitally-driven world wherever monitors reign supreme and instant interaction drowns out the subtleties of language, the profound techniques and mental nuances concealed within phrases often get unheard. However, located within the pages of **Stereochemistry Of Coordination Compounds** a charming literary value blinking with organic thoughts, lies a fantastic journey waiting to be undertaken. Penned by a talented wordsmith, that wonderful opus attracts visitors on an introspective trip, gently unraveling the veiled truths and profound impact resonating within the cloth of every word. Within the emotional depths of this touching evaluation, we will embark upon a sincere exploration of the book's key subjects, dissect its charming publishing type, and yield to the powerful resonance it evokes strong within the recesses of readers' hearts.

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