

Article

# Chiral Separation of Oxazolidinone Analogs by Capillary Electrophoresis Using Anionic Cyclodextrins as Chiral Selectors: Emphasis on Enantiomer Migration Order

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**Abstract:** Comparative chiral separations of enantiomeric pairs of four oxazolidinone and two related thio-derivatives were performed by capillary electrophoresis, using cyclodextrins (CDs) as chiral selectors. Since the selected analytes are neutral, the enantiodiscrimination capabilities of nine anionic CD derivatives were determined, in 50 mM phosphate buffer pH = 6. Unanimously, the most successful chiral selector was the single isomeric heptakis-(6-sulfo)- $\beta$ -cyclodextrin (HS- $\beta$ -CD), which resulted in the highest enantioresolution values out of the CDs applied for five of the six enantiomeric pairs. The enantiomer migration order (EMO) was the same for two enantiomeric pairs, irrespective of the CD applied. However, several examples of EMO reversals were obtained in the other cases. Interestingly, changing from randomly substituted, multi-component mixtures of sulfated- $\beta$ -CD to the single isomeric chiral selector, enantiomer migration order reversal occurred for two enantiomeric pairs and similar observations were made when comparing heptakis-(2,3-di-O-methyl-6-O-sulfo)- $\beta$ -CD, (HDMS- $\beta$ -CD) with HS- $\beta$ -CD. In several cases, cavity-size-dependent, and substituent-dependent EMO reversals were also observed. Minute differences in the structure of the analytes were also responsible for several cases of EMO reversal. The present study offers a complex overview of the chiral separation of structurally related oxazolidinones, and thio-analogs, highlighting the importance of the adequate choice of chiral selector in this group of compounds, where enantiomeric purity is of utmost importance.

**Keywords:** oxazolidinone; reversal of enantiomeric migration order; cyclodextrin; CE; enantioseparation; chiral building block



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## 1. Introduction

Given that there are usually pharmacological and/or pharmacokinetic differences between individual enantiomers, the importance of stereochemistry is gaining greater attention in drug research and development [1]. There are primarily two main approaches to obtain enantiomerically pure compounds: chiral resolution and asymmetric synthesis, by using enantiomerically pure substrates, reagents, solvents, or catalysts [2]. Among the various protocols developed to induce chirality to a substrate, the use of chiral auxiliaries stands out as offering high levels of stereoselectivity and reliability [3]. Their role in asymmetric reactions is comparable to those of different protection and deprotection reactions

# Chiral Co Crystallization For Enantiomer Separation

**Wolfgang Guggemos**



## **Chiral Co Crystallization For Enantiomer Separation:**

**Enantiomer Separation** Fumio Toda, 2007-11-04 In spite of important advances in asymmetric synthesis chiral compounds cannot all be obtained in a pure state by asymmetric synthesis As a result enantiomer separation remains an important technique for obtaining optically active materials Although asymmetric synthesis is a once only procedure an enantiomer separation process can be repeated until the optically pure sample is obtained This book discusses several new enantiomer separation methods using modern techniques developed by experts in the field These methods consist mainly of the following three types 1 Enantiomer separation by inclusion complexation with a chiral host compound 2 Enantiomer separation using biological methods 3 Enantiomer separation by HPLC chromatography using a column containing a chiral stationary phase Separation of a racemic compound has been called optical resolution or simply resolution Nowadays the descriptions enantiomer resolution or enantiomer separation are also commonly used Accordingly Enantiomer Separation is used in the title of this book The editor and all chapter contributors hope that this book is helpful for scientists and engineers working in this field

**Separations and Reactions in Organic Supramolecular Chemistry** Fumio Toda, Roger Bishop, 2004-04-21 A new volume in the Perspectives in Supramolecular Chemistry series focusing on separating supramolecular structures a key step in supramolecular chemistry Two guest editors have been at the forefront of the development of chromatographical methods to deal with supramolecular systems Reactions of supramolecular structures show the way into the future of chemistry Fumio Toda is one of the driving forces in the development of supramolecular separation systems A practical title in the prestigious Perspectives in Supramolecular Chemistry series

**Advances in Organic Crystal Chemistry** Seiya Kobatake, Hidehiro Uekusa, 2025-07-28 This book summarizes and records the recent notable advances in diverse topics in organic crystal chemistry which has made substantial progress along with the rapid development of a variety of analysis and measurement techniques for solid organic materials This volume follows previously published volumes that are prepared periodically at least every 5 years with contributions by prominent authors in Japan and from abroad The first volume was published in 2015 which systematically summarized the remarkable progress in assorted topics of organic crystal chemistry using organic solids and organic inorganic hybrid materials The second volume published in 2020 presented advances in organic solid state chemistry mainly from 2016 to 2020 The present volume also shows the progress of organic solid state chemistry especially focusing on crystal growth and crystal structure design that has been achieved mainly in the last 5 years or so Crystal growth and crystal structure design described in this book is helpful for not only readers who study organic crystals but also those who study inorganic crystals materials chemistry coordination chemistry and organometallic chemistry

**Stereoselective Synthesis of Drugs and Natural Products** Vasyly Andrushko, Natalia Andrushko, 2013-08-16 Brings together the best tested and proven stereoselective synthetic methods Both the chemical and pharmaceutical industries are increasingly dependent on stereoselective synthetic methods and strategies

for the generation of new chiral drugs and natural products that offer specific 3 D structures With the publication of Stereoselective Synthesis of Drugs and Natural Products researchers can turn to this comprehensive two volume work to guide them through all the core methods for the synthesis of chiral drugs and natural products Stereoselective Synthesis of Drugs and Natural Products features contributions from an international team of synthetic chemists and pharmaceutical and natural product researchers These authors have reviewed the tremendous body of literature in the field in order to compile a set of reliable tested and proven methods alongside step by step guidance This practical resource not only explores synthetic methodology but also reaction mechanisms and applications in medicinal chemistry and drug discovery The publication begins with an introductory chapter covering general principles and methodologies nomenclature and strategies of stereoselective synthesis Next it is divided into three parts Part One General Methods and Strategies Part Two Stereoselective Synthesis by Bond Formation including C C bond formation C H bond formation C O bond formation C N bond formation Other C heteroatom formation and other bond formation Part Three Methods of Analysis and Chiral Separation References in every chapter serve as a gateway to the literature in the field With this publication as their guide chemists involved in the stereoselective synthesis of drugs and natural products now have a single expertly edited source for all the methods they need

**Solid-State Materials in Pharmaceutical Chemistry** Stephen R. Byrn, George Zografi, Xiaoming (Sean) Chen, 2025-10-28 Updated and expanded information on the properties of pharmaceutical solids and their impact on drug product performance quality and stability Solid State Materials in Pharmaceutical Chemistry provides readers with a comprehensive and up to date resource for understanding and controlling the solid state properties of pharmaceutical materials enabling the development of safe and effective medicines including small molecule compounds peptides proteins and nucleotides This new edition covers the significant transformations in the landscape of pharmaceutical research development and manufacturing since the previous edition was published presenting both novel challenges and unprecedented opportunities New chapters in this edition cover physical and chemical properties of RNA therapeutics a frontier to many life saving medicines and vaccines including Covid vaccines and final stage drug substance manufacturing and control addressing challenges in API process development including impurity purging chiral separation final form preparation particle size reduction and nitrosamine control Readers will also find other updated topics including bulk and surface properties of solids lipid nanoparticles applications of pharmaceutical solvates in impurity purging and final form preparation pharmaceutical cocrystal engineering to enable chiral separation the emerging technique of microcrystal electron diffraction in solid form characterization poor wettability of APIs oral delivery of peptides such as semaglutide injectable drug device combination products and N nitrosamine control in drug product This updated and revised Second Edition still features Physical and chemical properties of solid state pharmaceuticals such as amorphous forms mesophases polymorphs hydrates solvates salts co crystals nano particles and solid dispersions Characterization techniques for solid form

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**Science and Technology of Separation Membranes** Tadashi Uragami, 2017-03-14 Offers a comprehensive overview of membrane science and technology from a single source Written by a renowned author with more than 40 years experience in membrane science and technology and polymer science Covers all major current applications of membrane technology in two definitive volumes Includes academic analyses applications and practical problems for each existing membrane technology Includes novel applications such as membrane reactors hybrid systems and optical resolution as well as membrane fuel cells

**Chiral Separation Techniques** G. Subramanian, 2001 This is a completely revised and updated sequel to A Practical Approach to Chiral Separations by Liquid Chromatography by the same editor The scope has been extended to further chiral separation techniques like electrophoresis membrane separations or biological assays More emphasis is put on preparative separation techniques From reviews of the previous edition A team of experts from academic and industrial laboratories throughout the world have compiled their findings and experience to make this book an exceptionally timely and unique contribution to the field European Journal of Drug Metabolism The dense mass of information contained in this book will make it a valuable resource Chemical Engineering Research this is a worthwhile addition to the expanding chiral literature and the book should be of value to those working in this field The Analyst

*Chiral Separations and Stereochemical Elucidation* Quezia Bezerra Cass, Maria Elizabeth Tiritan, João Marcos Batista Junior, Juliana Cristina Barreiro, 2023-03-29 An expert resource for chemists using stereochemical analysis methods In Chiral Separations and Stereochemical Elucidation Fundamentals Methods and Applications a team of distinguished researchers delivers a robust and authoritative discussion of the theoretical fundamentals of chiral separation the most commonly used chiral selectors and stereochemical elucidation methods The book offers expert discussions of a variety of chiral separation methods by gas chromatography GC supercritical fluid chromatography SFC capillary electrophoresis CE and liquid chromatography LC The authors also describe several methods for stereochemical elucidation including X ray crystallography nuclear magnetic resonance spectroscopy and chiroptical methods The explored material is ideal for practicing chemists seeking a resource to help them guide method development and optimization or to explain quality control complements during target compound production Readers will also find A thorough introduction to the most important advances and applications in LC GC CE SFC and preparative chromatography

Comprehensive explorations of the role of 2D LC for chiral separation methods development and applications Practical discussions of the design mechanisms and applications of the most commonly used chiral selectors Fulsome treatments of the theoretical backgrounds advantages limitations and applications of stereochemical elucidation methods Perfect for academic and industrial chemists specially in organic analytical chemistry and pharmaceutical analysis Chiral Separations and Stereochemical Elucidation Fundamentals Methods and Applications will also benefit biochemists environmental analysts forensic and medicinal chemists as well as natural product chemists and those involved with stereochemistry or structural elucidation

**Co-crystals** Christer B Aakeröy, Abhijeet S Sinha, 2018-07-13 Multi component crystalline systems or co crystals have received tremendous attention from academia and industry alike in the past decade Applications of co crystals are varied and are likely to positively impact a wide range of industries dealing with molecular solids Co crystallization has been used to improve the properties and performance of materials from pharmaceuticals to energetic materials as well as for separation of compounds This book combines co crystal applications of commercial and practical interest from diverse fields in to a single volume It also examines effective structural design of co crystals and provides insights into practical synthesis and characterization techniques Providing a useful resource for postgraduate students new to applied co crystal research and crystal engineering it will also be of interest to established researchers in academia or industry

**Sustainable Process Engineering** Andrzej Benedykt Koltuniewicz, 2014-08-19 The vital need for alternative resources and reaction routes environmentally friendly and economically feasible industrial chemical processes has become a ubiquitous reality This very timely introductory text covers new materials processes and industry sectors nanotechnology microreactors membrane separations hybrid processes clean technologies energy savings and safe production of energy renewables and biotechnology Some completely new processes for the solid liquid systems are also discussed in detail thus creating new opportunities of sustainable development not only in industrial practice

**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 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 Industrial Chemical Separation Timothy C. Frank, Bruce S.

Holden, 2023-08-07 A fresh new treatment written by industry insiders this work gives readers a remarkably clear view into the world of chemical separation The authors review distillation extraction adsorption crystallization and the use of membranes providing historical perspective explaining key features and offering insights from personal experience The book is for engineers and chemists with current or future responsibility for chemical separation on a commercial scale in its design operation or improvement or for anyone wanting to learn more about chemical separation from an industrial point of view The result is a compelling survey of popular technologies and the profession one that brings the art and craft of chemical separation to life Ever wonder how popular separation technologies came about how a particular process functions or how mass transfer units differ from theoretical stages Or perhaps you want some pointers on how to begin solving a separation problem You will find clear explanations and valuable insights into these and other aspects of industrial practice in this refreshing new survey **Engineering Crystallography: From Molecule to Crystal to Functional Form** Kevin J.

Roberts, Robert Docherty, Rui Tamura, 2017-07-18 This book highlights the current state of the art regarding the application of applied crystallographic methodologies for understanding predicting and controlling the transformation from the molecular to crystalline state with the latter exhibiting pre defined properties This philosophy is built around the fundamental principles underpinning the three inter connected themes of Form what Formation how and Function why Topics covered include molecular and crystal structure chirality and ferromagnetism supramolecular assembly defects and reactivity morphology and surface energetics Approaches for preparing crystals and nano crystals with novel physical chemical and mechanical properties include crystallisation seeding phase diagrams polymorphic control chiral separation ultrasonic techniques and mechano chemistry The vision is realised through examination of a range of advanced analytical characterisation techniques including in situ studies The work is underpinned through an unprecedented structural perspective of molecular features solid state packing arrangements and surface energetics as well as in situ studies This work will be of interest to researchers industrialists intellectual property specialists and policy makers interested in the latest developments in the design and supply of advanced high added value organic solid form materials and product

composites     *Encyclopedia of Supramolecular Chemistry - Two-Volume Set (Print)* Jerry L. Atwood,Jonathan W. Steed,2013-10-09 The two volume Encyclopedia of Supramolecular Chemistry offers authoritative centralized information on a rapidly expanding interdisciplinary field User friendly and high quality articles parse the latest supramolecular advancements and methods in the areas of chemistry biochemistry biology environmental and materials science and engineering physics computer science and applied mathematics Designed for specialists and students alike the set covers the fundamentals of supramolecular chemistry and sets the standard for relevant future research     *Principles of Asymmetric Synthesis* Robert E. Gawley,Jeffrey Aube,2012-05-29 The world is chiral Most of the molecules in it are chiral and asymmetric synthesis is an important means by which enantiopure chiral molecules may be obtained for study and sale Using examples from the literature of asymmetric synthesis this book presents a detailed analysis of the factors that govern stereoselectivity in organic reactions After an explanation of the basic physical organic principles governing stereoselective reactions the authors provide a detailed annotated glossary of stereochemical terms A chapter on Practical Aspects of Asymmetric Synthesis provides a critical overview of the most common methods for the preparation of enantiomerically pure compounds techniques for analysis of stereoisomers using chromatographic spectroscopic and chiroptical methods The authors then present an overview of the most important methods in contemporary asymmetric synthesis organized by reaction type Thus there are four chapters on carbon carbon bond forming reactions one chapter on reductions and one on oxidations carbon oxygen and carbon nitrogen bond forming reactions This organization allows the reader to compare the leading methods for asymmetric synthesis in an appropriate context A highlight of the book is the presentation and discussion of transition states at the current level of understanding for important reaction types In addition extensive tables of examples are used to give the reader an appreciation for the scope of each reaction Finally leading references are provided to natural product synthesis that has been accomplished using a given reaction as a key step Authoritative glossary to aid understanding of stereochemical terminology Explanations of the key factors influencing stereoselectivity with numerous examples organized by reaction type A handy reference guide to the literature of asymmetric synthesis for practitioners in the field     *Crystal Engineering: A Textbook* Gautam R Desiraju,Jagadese J Vittal,Arunachalam Ramanan,2011-06-20 This book is important because it is the first textbook in an area that has become very popular in recent times There are around 250 research groups in crystal engineering worldwide today The subject has been researched for around 40 years but there is still no textbook at the level of senior undergraduates and beginning PhD students This book is expected to fill this gap The writing style is simple with an adequate number of exercises and problems and the diagrams are easy to understand This book consists major areas of the subject including organic crystals and coordination polymers and can easily form the basis of a 30 to 40 lecture course for senior undergraduates     **Encyclopedia of Supramolecular Chemistry** J. L. Atwood,Jonathan W. Steed,2004 Covers the fundamentals of supramolecular chemistry supramolecular advancements and methods in the

areas of chemistry biochemistry biology environmental and materials science and engineering physics computer science and applied mathematics

**Characterisation of Porous Solids VIII** Stefan Kaskel, 2009 This book is the Proceedings of the 8th International Symposium on the Characterisation of Porous Solids The conference is one of a series held every three years which covers developments in methods for the characterisation of porous materials and applications of those methods COPS VIII is concerned with fundamental and applied research on the characterisation of the structure of porous materials and the relationship between structure and material performance The scope includes experimental characterisation methods such as X Ray diffraction NMR adsorption mercury intrusion and calorimetry theoretical and simulation methods used to interpret experimental data such as molecular simulation classical and statistical mechanical theory and pore network modelling and applied research on the impact of measured material properties on performance in applications This book will appeal to both academics and commercial researchers

**Amino Acids, Peptides and Proteins** Maxim Ryadnov, Ferenc Hudecz, 2017-11-29 Amino Acids Peptides and Proteins comprises a comprehensive and critical review of significant developments at the biology and chemistry interface Compiled by leading researchers in their subject this volume incorporates current trends and emerging areas in topics such as magnetic resonance studies of membrane active peptides proteins and peptides for the diagnosis and therapy of Leishmania donovani parasite infections and advances in the design of ligands interacting with proteases causing infectious respiratory syndrome Appealing broadly to researchers in academia and industry it will be of great benefit to any researcher wanting a succinct reference on developments in this area now and looking to the future

**Advances in Chromatography, Volume 46** Eli Grushka, Nelu Grinberg, 2007-11-05 Written by leading international experts in academia and industry Advances in Chromatography Volume 46 presents all new chapters with thorough reviews on the latest developments in the field Volume 46 includes new advances in two dimensional gas chromatography reversed phase liquid chromatography shape selectivity and supercri

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## Chiral Co Crystallization For Enantiomer Separation Introduction

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