

Article

Biological Applications of Electron Paramagnetic Resonance Viscometry Using a ^{13}C -Labeled Trityl Spin Probe

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Abstract: Alterations in viscosity of biological fluids and tissues play an important role in health and diseases. It has been demonstrated that the electron paramagnetic resonance (EPR) spectrum of a ^{13}C -labeled trityl spin probe (^{13}C -dFT) is highly sensitive to the local viscosity of its microenvironment. In the present study, we demonstrate that X-band (9.5 GHz) EPR viscometry using ^{13}C -dFT provides a simple tool to accurately measure the microviscosity of human blood in microliter volumes obtained from healthy volunteers. An application of low-field L-band (1.2 GHz) EPR with a penetration depth of 1–2 cm allowed for microviscosity measurements using ^{13}C -dFT in the living tissues from isolated organs and in vivo in anesthetized mice. In summary, this study demonstrates that EPR viscometry using a ^{13}C -dFT probe can be used to noninvasively and rapidly measure the microviscosity of blood and interstitial fluids in living tissues and potentially to evaluate this biophysical marker of microenvironment under various physiological and pathological conditions in preclinical and clinical settings.

Keywords: EPR; microviscosity; trityl radical; viscometry; blood viscosity; interstitial fluid viscosity



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1. Introduction

Complex microenvironments of body fluids, such as blood, cerebrospinal, synovial, urine, and interstitial fluids, carry numerous potential biomarkers to provide a wealth of information about physiological status [1]. Blood viscosity is defined by its components, such as blood cells, platelets, proteins, fibrinogen, antibodies, cytokines/chemokines, and lipoproteins [2–4]. Increased blood viscosity has been implicated in greater flow resistance and a high incidence of circulatory complications [5,6]. Under pathological conditions, the concentrations of the components of the blood are altered [3]. Whole blood viscosity is a major determinant of macro- and microvascular flow, and increased blood viscosity has been described in patients with coronary and peripheral disease [7]. It has also been shown that blood viscosity is elevated in breast cancer patients [3]. Therefore, quantitative measurements of the viscosity of blood may provide valuable information for disease detection and treatment monitoring.

For living tissues, the viscosity of extracellular interstitial fluids plays an important role in regulating cellular functions and the physiological function of whole organs [1]. Changes in extracellular microenvironment composition and fluidity can affect cellular processes and a cell's response to drugs. Hence, tissue-specific measurements of the

Biological Applications Of Electron Spin Resonance

Philip Henri Rieger



Biological Applications Of Electron Spin Resonance:

Biological Applications of Electron Spin Resonance Harold M. Swartz, James R. Bolton, Donald C. Borg, 1972 **New Applications of Electron Spin Resonance** M. Ikeya, 1993 This is the first book covering an interdisciplinary field between microwave spectroscopy of electron paramagnetic resonance EPR or electron spin resonance ESR and chronology science radiation dosimetry and ESR EPR imaging in material sciences The main object is to determine the elapsed time with ESR from forensic medicine to the age and radiation dose in earth and space science This book is written primarily for earth scientists as well as for archaeologists and for physicists and chemists interested in new applications of the method This book can serve as an undergraduate and graduate school textbook on applications of ESR to geological and archaeological dating radiation dosimetry and microscopic magnetic resonance imaging MRI Introduction to ESR and chronology science and principle of ESR dating and dosimetry are described with applications to actual problems according to materials Electron Spin Resonance Philip Henri Rieger, 2007 This book describes in mathematical terms the extraction of useful information from ESR spectra as applied to paramagnetic organic inorganic and organometallic molecules It lays a firm groundwork for understanding more sophisticated experiments which the availability of newer commercial instruments has made possible It takes the reader step by step through obtaining and interpreting ESR spectra of paramagnetic molecules The mathematical basis of each observed phenomena are detailed and examples given In particular there is a detailed discussion of 2nd order perturbation theory treatment of the Spin Hamiltonian for non coincident G and A axes **Electron Spin Resonance Vol 2** R. O. C. Norman, 1973 This product is not available separately it is only sold as part of a set There are 750 products in the set and these are all sold as one entity **Biological Applications of Electron Spin Resonance** Carlo B. Azzoni, Gian L. DelNero, 1982 *Electron Spin Resonance* John Wertz, 2012-12-06 In the twenty five years since its discovery by Zavoiskii the technique of electron spin resonance ESR spectroscopy has provided detailed structural information on a variety of paramagnetic organic and inorganic systems It is doubtful that even much later than 1945 any chemist would have been so bold as to predict the great diversity of systems which have proved amenable to study by ESR spectroscopy In this book we have attempted to provide numerous examples of actual ESR spectra to illustrate the wide scope of application No attempt has been made to present a comprehensive coverage of the literature in any field but references to reviews and key articles are given throughout the book This introductory textbook had its origin in lecture notes prepared for an American Chemical Society short course on electron spin resonance The present version is the result of extensive revision and expansion of the original notes Experience with such courses has convinced us that there are large numbers of chemists physicists and biologists who have a strong interest in electron spin resonance The mathematical training of most of the short course students is limited to calculus Their contact with theories of molecular structure is largely limited to that obtained in an elementary physical chemistry course It is to an audience of such background that this book is directed Biological and

Biochemical Applications of Electron Spin Resonance David John Edward Ingram,1969 *Biological and Biochemical Applications of Electron Spin Resonance* INGRAM D. J.,1995-12-31 **Biological and Biochemical Applications of Electron Spin Resonance** David John Edward Ingram,1969 **Electron Spin Resonance** P B Ayscough,2007-10-31

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Derivative Spectrophotometry and Electron Spin Resonance (ESR) Spectroscopy for Ecological and Biological Questions Vladimir S. Saakov,Valery Z. Drapkin,Alexander I. Krivchenko,Eugene V. Rozengart,Yuri V. Bogachev,Mikhail N. Knyazev,2012-10-06 This book provides a multidisciplinary overview to the application of high order derivative spectrophotometry and Electron Spin Resonance ESR spectroscopy in biology and ecology The characteristics of the principle methods as well as the generation of reliable spectra are discussed in general terms allowing the reader to gain an idea of these methods potentials Furthermore the authors give an extended overview to the spectroscopic and spectrophotometric analysis of specific biological materials This volume is a well condensed description of an analytical method and a clear review to its application in biology and related fields and an essential tool for researchers who are new in the field of spectroscopic methods and their applications in the life sciences **Structural and Resonance Techniques in Biological Research** Denis Rousseau,2012-12-02 Structural and Resonance Techniques in Biological Research discusses the fundamentals and applications of nuclear magnetic resonance electron spin resonance Mossbauer spectroscopy x ray absorption spectroscopy macromolecular crystallography and small angle x ray scattering and diffraction The chapters are aimed at a level such that only a general understanding of chemistry and biology is required The objective is to present material in a way that allows the research worker to assess quickly the applicability utility and significance of the specific technique to his or her problem or field of interest Together with Optical Techniques in Biological Research this book marks the introduction of a new series of volumes Physical Techniques in Biology and Medicine which is intended to replace a

previous treatise *Physical Techniques in Biological Research* Carlo Bruno Azzoni, 1982

Biological Applications of Electron Spin Resonance
Electron Paramagnetic Resonance Investigations of Biological Systems by Using Spin Labels, Spin Probes, and Intrinsic Metal Ions Part A, 2015-10-05

Electron Paramagnetic Resonance Investigations of Biological Systems by Using Spin Labels Spin Probes and Intrinsic Metal Ions Part A B are the latest volumes in the *Methods in Enzymology* series continuing the legacy of this premier serial with quality chapters authored by leaders in the field This volume covers research methods centered on the use of Electron Paramagnetic Resonance EPR techniques to study biological structure and function Timely contribution that describes a rapidly changing field Leading researchers in the field

Broad coverage Instrumentation basic theory data analysis and applications

Electron Paramagnetic Resonance in Biochemistry and Medicine Rafik Galimzyanovich Sajfutdinov, Lyudmila Ivanovna Larina, Tamara Il' nichna Vakul'skaya, Mikhail Grigor'evich Voronkov, 2006-04-11

Electron Paramagnetic Resonance EPR spectroscopy also sometimes termed Electron Spin Resonance spectroscopy has manifold potential uses in biochemistry and medicine The paramount importance of EPR spectroscopy applied to biological tissues and fluids is that it identifies the changes in redox processes that contribute to disease EPR spectroscopy has come a long way from its original use to detect malignant tumors For example the development and later refinement of methods of low temperature registration of biological tissues widened the scope of EPR spectroscopy Innovations made possible by the introduction of spin labels probes and traps made EPR spectroscopy ever more applicable to biochemistry and medicine to the point where in vivo studies are being carefully considered This comprehensive book discusses spectra of many tissues and bodily fluids and the quantitative nature of paramagnetic centers in both normal individuals and patients suffering from a variety of diseases Special attention is given to the EPR examination of bio molecules such as enzymes polypeptides vitamins lipids hydrocarbons etc which play an essential role in human activity This book will be of great interest to physicians specializing in many different areas Similarly biologists biochemists biophysicists and chemists will find this book very useful It has also been written so that it may be used as a textbook at graduate level

Electron Spin Resonance M C R Symons, 2007-10-31

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Handbook of Microwave Technology T. Koryu Ishii, 1995-10-16 Handbook of Microwave Technology **Magnetic Sensors for Biomedical Applications** Hadi Heidari, Vahid Nabaei, 2019-12-24 An important guide that reviews the basics of magnetic biosensor modeling and simulation Magnetic Sensors for Biomedical Applications offers a comprehensive review of magnetic biosensor modelling and simulation The authors noted experts on the topic explore the model s strengths and weaknesses and discuss the competencies of different modelling software including homemade and commercial for example Multi physics modelling software The section on sensor materials examines promising materials whose properties have been used for sensing action and predicts future smart materials that have the potential for sensing application Next the authors present classifications of sensors that are divided into different sub types They describe their working and highlight important applications that reveal the benefits and drawbacks of relevant designs The book also contains information on the most recent developments in the field of each sensor type This important book Provides an even treatment of the major foundations of magnetic biosensors Presents problem solution methods such as analytical and numerical Explains how solution methods complement each other and offers information on their materials design computer aided modelling and simulation optimization and device fabrication Describes modeling work challenges and solutions Written for students in electrical and electronics engineering physics chemistry biomedical engineering and biology Magnetic Sensors for Biomedical Applications offers a guide to the principles of biomagnetic sensors recent developments and reveals the impact of sensor modelling and simulation on magnetic sensors

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