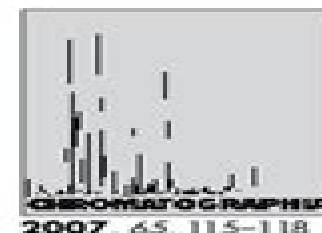


Determination of Bromate and Bromide in Seawater by Ion Chromatography, with an Ammonium Salt Solution as Mobile Phase, and Inductively Coupled Plasma Mass Spectrometry



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Abstract

A method has been developed for determination of bromate and bromide in water containing high concentrations of chloride (e.g. seawater). Separation of bromate and bromide on an anion-exchange column was followed by ICP-MS detection. To reduce interference of chloride with determination of bromate and bromide, and to avoid clogging, ammonium salts, for example $\text{NH}_4\text{H}_2\text{PO}_4$, $(\text{NH}_4)_2\text{HPO}_4$, $(\text{NH}_4)_2\text{CO}_3$, and NH_4NO_3 were examined as mobile-phase components. It was found that mobile phase containing 20 mM NH_4NO_3 at pH 5.80 was compatible with the anion-exchange column and enabled reasonable resolution and separation of bromate and bromide within 7 min. Detection limits for bromate and bromide ranged from 2.0 to 3.0 $\mu\text{g L}^{-1}$ for direct injection of 50 μL sample without matrix elimination. The proposed method was used for analysis of bromate and bromide in seawater.

Keywords

Column liquid chromatography
Ion chromatography-ICP-MS
Ammonium buffers
Bromate and bromide in seawater

Introduction

Among the wide variety of techniques available for determination of bromine species, anion-exchange chromatography (IC) with a variety of detection methods, including conductivity, spectrophotometry, and inductively coupled plasma mass spectrometry (ICP-MS), is often used [1]. Suppressed IC with conductivity detection, the most common procedure for

analysis of bromate, bromide, and other anions [1–3], is based on suppression of the conductivity of the mobile phase by use of a suppressor column. Chloride is often present in 100-fold excess over bromide in seawater and, because the column is overloaded when the chloride concentration is very large, it interferes by eluting very near to bromate and bromide. Although an approach based on post-column reaction (PCR) and UV

detection is an attractive alternative for determination of bromine species [4–7], these methods may not be suitable for analysis of seawater, in which chloride is present in very large excess over bromide [8]. A new mode of IC separation, electrostatic IC, has recently been used for analysis of seawater to avoid the matrix problem [9, 10].

IC coupled with ICP-MS has been used for the determination of inorganic anions [1] because ICP-MS has several advantages, for example high selectivity in SIM mode and a wide linear dynamic range of detection [11]. IC-ICP-MS with both suppressed ion chromatography [12–16] and non-suppressed anion chromatography has recently been successfully used for determination of bromate and bromide in a variety of matrices [17–21]. Although IC-ICP-MS methods are useful for determination of bromate and bromide, they have not yet been used for analysis of bromide in seawater.

For these reasons we have investigated use of a variety of ammonium salts as mobile phase components for determination of bromate and bromide in seawater. Because seawater contains a high concentration of Cl^- , it might be difficult to separate Cl^- from bromate by anion-exchange chromatography. Because ICP-MS is highly specific and sensitive, however, in contrast with conventional detection in IC, for example conductivity and UV, even at high matrix concentrations it is possible to use

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Environmental Applications of Instrumental Chemical Analysis Mahmood Barbooti, 2015-04-15 This book is a comprehensive review of the instrumental analytical methods and their use in environmental monitoring site assessment and remediation follow up operations The increased concern about environmental issues such as water pollution air pollution accumulation of pollutants in food global climate change and effective remediation processes necessitate the precise determination of various types of chemicals in environmental samples In general all stages of environmental work start with the evaluation of organic and inorganic environmental samples This important book furnishes the fundamentals of instrumental chemical analysis methods to various environmental applications and also covers recent developments in instrumental chemical methods Covering a wide variety of topics in the field the book Presents an introduction to environmental chemistry Presents the fundamentals of instrumental chemical analysis methods that are used mostly in the environmental work Examines instrumental methods of analysis including UV Vis FTIR atomic absorption induced coupled plasma emission electrochemical methods like potentiometry voltametry coulometry and chromatographic methods such as GC and HPLC Presents newly introduced chromatographic methodologies such as ion electrophoresis and combinations of chromatography with pyrolysis methods are given Discusses selected methods for the determinations of various pollutants in water air and land Readers will gain a general review of modern instrumental method of chemical analysis that is useful in environmental work and will learn how to select methods for analyzing certain samples Analytical instrumentation and its underlying principles are presented along with the types of sample for which each instrument is best suited Some noninstrumental techniques such as colorimetric detection tubes for gases and immunoassays are also discussed

Analysis of Seawater Crompton, 2012-12-02 Analysis of Seawater deals with the investigation of the micro constituents in seawater in terms of nutrient content and environmental concerns The book describes sampling determination of anions analysis of dissolved gases and metal preconcentration techniques The book also deals with monitoring radioactive elements the determination of seawater organics organometallic compounds and the oxygen demand parameters in seawater It describes in detail surface and deep water sampling the types of devices used storage preservation and prevention of contamination during sample analysis In examining dissolved gases the investigator can use the amperometric titrimetric method with some reservations on chlorine the ultraviolet method on ozone electron capture gas chromatography on nitric oxide and also the flow injection analysis on hydrogen sulphide The methods for determining metals in seawater concern either for single element or for groups of elements The investigator should always initiate various pre concentration techniques when determining metals due to their low concentration and occurrence in seawater The investigator uses various methods to determine different radioactive compounds such as uranium polonium thorium radium barium radon plutonium strontium 90 and cesium 137 The book can be beneficial for meteorologists environmentalists marine ecologists biologists oceanographers

fisheries experts for students studying hydrology meteorology as well as for river and lake authorities Analysis of Seawater T.R. Crompton,2006-08-02 It is only in the past few years that methods of adequate sensitivity have become available for true ultra trace metal determinations in water In the case of organics in seawater it has now become possible to resolve the complex mixtures of organics in seawater and achieve the required very low detection limits Fortunately the interest in micro constituents in the seawater both from the environmental and the nutrient balance points of view has coincided with the availability of advanced instrumentation capable of meeting the analytical needs This complete and up to date compilation of the currently employed proven methods for the chemical analysis of seawaters includes 45 tables and 48 figures The author presents the methods in a logical manner so that the reader can readily learn how to perform them and understand the types of instrumentation available It helps the practitioner to implement these methods successfully into his laboratory and to apply them quickly and reliably In addition the detailed description of each method enables the analyst to set up new analytical methods meeting the needs for the detection of new analytes The volume covers all aspects of the analysis of seawater using both classical and the most advanced recently introduced physical techniques It is an invaluable source for the analysts oceanographers fisheries experts politicians and decision maker engaged in seawater environmental protection *Handbook of Water Analysis* Leo M.L. Nollet,Leen S. P. De Gelder,2000-06-27 This work details water sampling and preservation methods by enumerating the different ways to measure physical chemical organoleptical and radiological characteristics It provides step by step descriptions of separation residue determination and cleanup techniques for a variety of fresh and salt waters It also discusses information regarding the analysis and detection of bacteria and algae

Determination of Anions in Natural and Treated Waters T R Crompton,2003-09-02 As environmental controls are lagging behind industrial development metals are an increasing hazard to humans animal and plant life Bioaccumulation of metals through the food chain creates a serious impact on public health yet analytical techniques for detecting the often low concentrations of contaminants are poorly understood **Determination of Anions in Natural and Treated Waters** draws together the scattered literature and presents in a systematic fashion the latest available analytical techniques for detecting anions in non saline and saline natural and treated water Broad outlines of different methods and their applicability in certain situations are given allowing the chemist to choose appropriate test methods **Reviews of Environmental**

Contamination and Toxicology Volume 211 David M. Whitacre,2011-02-03 **Reviews of Environmental Contamination and Toxicology** attempts to provide concise critical reviews of timely advances philosophy and significant areas of accomplished or needed endeavor in the total field of xenobiotics in any segment of the environment as well as toxicological implications

Operational and Environmental Consequences of Large Industrial Cooling Water Systems Sanjeevi Rajagopal,Henk A. Jenner,Vayalam P. Venugopalan,2012-01-07 The use of water for industrial purposes is of foremost importance It is used as a coolant and industrial activities dealing with power generation steel and iron paper and pulp and

oil require very large amounts of water. The industry therefore resorts to large scale abstraction of water from natural water bodies. This water is often treated with chemicals to combat operational problems like biofouling and corrosion. Such withdrawal and subsequent discharge of large amounts of water have the potential to impart significant impact on the recipient water body. The organisms drawn along with the cooling water as well as those residing at the discharge zone are subjected to a combination of mechanical, thermal and chemical stress on a continuous basis.

Handbook of Water Analysis, Third Edition Leo M.L. Nollet, Leen S. P. De Gelder, 2013-07-29. Extensively revised and updated. *Handbook of Water Analysis, Third Edition* provides current analytical techniques for detecting various compounds in water samples. Maintaining the detailed and accessible style of the previous editions, this third edition demonstrates water sampling and preservation methods by enumerating different ways to measure chemical and radiological characteristics. It gives step by step descriptions of separation, residue determination and clean up techniques. See What's New in the Second Edition. Includes five new chapters covering ammonia, nitrates, nitrites and petroleum hydrocarbons as well as organoleptical and algal analysis methodology. Compares older methods still frequently used with recently developed protocols and examines future trends. Features a new section regarding organoleptical analysis of water acknowledging that ultimately the consumers of drinking water have the final vote over its quality with respect to odor, flavor and color. The book covers the physical, chemical and other relevant properties of various substances found in water. It then describes the sampling, cleanup, extraction and derivatization procedures and concludes with detection methods. Illustrated with procedure flow charts and schematics, the text includes numerous tables categorizing methods according to type of component, origin of the water sample, parameters and procedures used and application range. With contributions from international experts, the book guides you through the entire scientific investigation starting with a sampling strategy designed to capture the real world situation as closely as possible and ending with an adequate chemometrical and statistical treatment of the acquired data. By organizing data into more than 300 tables, graphs and charts and supplementing the text with equations and illustrations, the editors distill a wealth of knowledge into a single accessible reference.

Methods of Seawater Analysis Klaus Grasshoff, Klaus Kremling, Manfred Ehrhardt, 2009-07-30. Since the book first appeared in 1976, *Methods of Seawater Analysis* has found widespread acceptance as a reliable and detailed source of information. Its second extended and revised edition, published in 1983, reflected the rapid pace of instrumental and methodological evolution in the preceding years. The development has lost nothing of its momentum and many methods and procedures still suffering their teething troubles then have now matured into dependable tools for the analyst. This is especially evident for trace and ultra trace analyses of organic and inorganic seawater constituents which have diversified considerably and now require more space for their description than before. Methods to determine volatile halocarbons, dimethyl sulphide, photosynthetic pigments and natural radioactive tracers have been added as well as applications of X-ray fluorescence spectroscopy and various electrochemical methods for trace metal

analysis Another method not previously described deals with the determination of the partial pressure of carbon dioxide as part of standardised procedures to describe the marine CO₂ system *Handbook of Ion Chromatography* Joachim Weiss, 2016-06-24 This three volume handbook is the standard reference in the field unparalleled in its comprehensiveness It covers every conceivable topic related to the expanding and increasingly important field of ion chromatography The fourth edition is completely updated and revised to include the latest developments in the instrumentation now stretching to three volumes to reflect the current state of applications Ion chromatography is one of the most widely used separation techniques of analytical chemistry with applications in fields such as medicinal chemistry water chemistry and materials science Consequently the number of users of this method is continuously growing underlining the need for an up to date reference A true pioneer of this method Joachim Weiss studied chemistry at the Technical University of Berlin Germany where he also received his PhD degree in Analytical Chemistry In 2002 he did his habilitation in Analytical Chemistry at the Leopold Franzens University in Innsbruck Austria where he is also teaching liquid chromatography Since 1982 Dr Weiss has worked at Dionex now being part of Thermo Fisher Scientific where he currently holds the position of Technical Director for Dionex Products within the Chromatography and Mass Spectrometry Division CMD of Thermo Fisher Scientific located in Dreieich Germany

Iodine Chemistry and Applications Tatsuo Kaiho, 2014-11-24 This book comprehensively covers iodine its chemistry and its role in functional materials reagents and compounds Provides an up to date detailed overview of iodine chemistry with discussion on elemental aspects characteristics properties iodides and halogen bonding Acts as a useful guide for readers to learn how to synthesize complex compounds using iodine reagents or intermediates Describes traditional and modern processing techniques such as starch copper blowing out and ion exchange resin methods Includes seven detailed sections devoted to the applications of iodine Characteristics Production Synthesis Biological Applications Industrial Applications Bioorganic Chemistry and Environmental Chemistry and Radioisotopes Features hot topics in the field such as hypervalent iodine mediated cross coupling reactions agrochemicals dye sensitized solar cells and therapeutic agents

Tracing Earth Surface Processes Using Novel Isotopic Approaches Kang-Jun Huang, Heng Chen, Wang Zheng, Mao-Yong He, 2023-02-27

The Distribution of Bromide in Water in the Floridan Aquifer System, Duval County, Northeastern Florida E. R. German, George Fred Taylor, 1995

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Analytical Methods for Drinking Water Philippe Quevauviller, K. Clive Thompson, 2005-12-13

Drinking water policies and research are intimately linked It is thanks to the scientific progress made over the last 25 years in identifying and controlling toxic products in drinking water that regulations have developed in such a way that the protection of public health from waterborne diseases has drastically improved The integration of research outputs into the policy making progress requires close cooperation among the scientific and policy communities which is not always straightforward Exchanges among scientific and policy making communities are certainly representing key elements of

progress for a better environmental protection In this respect analytical developments linked to drinking water are at the core of the science policy debate This book *Analytical Methods for Drinking Water Advances in Sampling and Analysis* reflects this awareness in joining recent analytical developments with policy considerations A first chapter gives an overview of EU and US drinking water policies as well as on standardization Analytical developments are described in depth in the second chapter focusing on bromate in drinking water The third chapter deals with the development of a sampling protocol for lead in drinking water thus mixing analytical development with standardization needs Finally the fourth chapter focuses on standardization aspects pre normative research related to materials in contact with drinking water This book written by experts in the field of drinking water policy and analysis illustrates recent scientific advances in this area which have contributed to policy development and will be of direct use to policy makers water scientists researchers and analytical laboratories

HDBK OF ION EXCHANGE RESINS Johann Korkisch, 1988-12-31 The six volume CRC Handbook of Ion Exchange Resins reviews the application of ion exchange resins to inorganic analytical chemistry Extracted from over 6 000 original publications it presents the information in over 1 000 tables complemented by concise descriptions of analytical methods involving virtually all the elements of the periodic table Also the ion exchange characteristics of the elements as well as other important information required by analysis using ion exchange resins are presented in separate tables The methods that allow the multi element analysis of complex matrices are emphasized This work includes a general discussion of the theoretical instrumental and other principles underlying the various applications of ion exchange resins in inorganic analytical chemistry with special attention focused on techniques based on ion chromatography

Cumulated Index Medicus, 1989

Handbook of Capillary and Microchip Electrophoresis and Associated Microtechniques James P. Landers, 2007-12-18 Now in its third edition this bestselling work continues to offer state of the art information on the development and employment of capillary electrophoresis With special emphasis on microseparations and microfluidics it features new chapters describing the use of microchip electrophoresis and associated microtechniques with a focus on the extraordinary breadth of work undertaken to expand CE methodologies in recent years Enhanced by contributions from leading international experts the Handbook of Capillary and Microchip Electrophoresis and Associated Microtechniques Third Edition remains a seminal reference for the chemistry biology and engineering fields

Annual Book of ASTM Standards ASTM International, American Society for Testing and Materials, 2004

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