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Platinum Metals in the Environment

Springer

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Foreword

Platinum group elements (PGE) naturally occur at trace concentrations in most surficial environments. Anthropogenic uses and emissions of PGE are now changing the environmental concentrations and biogeochemical cycle of these elements. Automobile catalysts, which were introduced in the 1970s, represent the largest PGE use, and are generally considered as the main source of PGE into the environment. Early PGE research in the 1970s and 1980s showed that PGE emissions from the catalysts caused elevated concentrations of these normally rare metals in the roadside environment. These first findings paved the way for further research, and by the mid-1990s an active research community, mainly in Europe, was investigating the emission and environmental occurrence of Pt, Pd, and Rh. The most important finding at the time was certainly that PGE are bioavailable, raising concern over the potential risks of this new contamination. It is also important to note that PGE research was supported by analytical developments and a clear focus on measurement accuracy. In recent years, PGE research was marked by a new shift. As automobile catalysts are being introduced in developing countries, the PGE research community is broadening and publications from Argentina, Brazil, China, Ghana, Mexico, or South Africa have appeared in the scientific literature. Congested cities and poor vehicle conditions are a new challenge and raise concern over potential PGE levels in the developing world.

Despite decades of active PGE research, many questions remain. Emissions rates from automobile catalysts are still uncertain. Other potential PGE sources have not been characterized in sufficient details. The finding of elevated PGE concentrations at remote sites shows that the geographical extent of PGE contamination is unclear. The physico-chemical forms and transformations of PGE are largely unknown. Further work is needed to assess the mobility and bioavailability of PGE under environmental conditions. Chronic effects on man and the environment are unclear. Answering these questions is key to assessing the potential risks of PGE emissions.

"Platinum Metals in the Environment" is the fourth book on the environmental PGE research published by Springer. I believe the publication of this new book is an important addition to the series. It brings together a wider research community

and provides an overview of the latest developments in PGE research. I warmly recommend this book to anyone interested in the PGE and their environmental relevance.

Gothenburg, June 2014 Sebastien Rauch

Preface

Platinum group elements (PGE) are six rare metals, platinum (Pt), palladium (Pd), iridium (Ir), rhodium (Rh), ruthenium (Ru), and osmium (Os), with excellent catalytic properties. Most notably, Pt, Pd, and Rh have been increasingly used in a number of applications over the last three decades. They are employed as catalysts in various chemical processes such as in hydrating and dehydrating reactions in the pharmaceutical industry and in the production of synthetic polymers, pesticides, and dyes. Following the initial introduction of automotive catalytic converters in North America in the 1970s, Pt, Pd, and Rh have been widely used as the catalysts of choice to reduce nitrous oxide, carbon monoxide, and hydrocarbon emissions in fuel exhaust. In fact, the largest application of PGE is the catalytic converter industry, which used 45, 78, and 80 % of the global production (supply + recycling) of Pt, Pd, and Rh in 2013, respectively (Johnson Matthey Platinum 2013, Interim Review).

While the use of automotive catalytic converters have greatly contributed to the improvement of air quality, it has also led to an accumulation of PGE in the environment, as these catalysts are emitted in small amounts due to mechanical, thermal, and chemical stressors. The potential environmental and human health effects of PGE emissions in automotive exhaust have been controversial, and the focus of much debate. In addition to automotive exhaust emissions, chemical facilities and the mining industry are primary emitters of PGE. Despite the solid body of research over the years, which has provided strong evidence regarding the increased presence of PGE in the atmosphere, large gaps in our knowledge regarding the possible environmental health implications of emissions still remain.

While original research on PGE emissions in the environment stems from the 1980s, considerable advancements have been made on this topic in the last 10 years, especially in terms of the development of analytical methodologies. Along with this, has been a rash and welcome increase in the number of studies examining various aspects of PGE emissions to the environment. New data has been generated regarding the chemical behavior of PGE, including their environmental mobility, solubility, bioaccessibility, and toxic potential. This edited volume, “Platinum Metals in the Environment”, builds upon three previously edited books by Zereini

and Alt, published by Springer-Verlag: “Emissionen von Platinmetallen: Analytik, Umwelt- und Gesundheitsrelevanz” (1999), “Anthropogenic Platinum-Group Element Emissions—Their Impact on Man and Environment” (2000), and “Palladium Emissions in the Environment: Analytical Methods, Environmental Assessment and Health Effects” (2006). The book compiles the most up-to-date results of interdisciplinary research on the topic of PGE emissions and introduces brand new insights into their chemical speciation, behavior, and potential to impact human health.

The book is grouped into five main parts, each consisting of contributions addressing similar aspects of each of the main topical areas: (1) Sources of PGE Emissions, (2) Analytical Methods for the Determination of PGE in Biological and Environmental Matrices, (3) Occurrence, Chemical Behavior, and Fate of PGE in the Environment, (4) Environmental Bioavailability and Biomonitoring of PGE, and (5) Human Health Exposures to PGE and Possible Risks.

A total of 61 scientists from 14 different countries contributed to this highly interdisciplinary volume, addressing topics covering the fields of chemistry, biology, geochemistry, and medicine. The range of topics covered and the research results presented and discussed will make this book of interest to experts both inside and outside of academia, as well as to post-secondary undergraduate and graduate students.

The editors would like to thank the authors and the reviewers for their timely efforts and valuable contributions to this highly successful, cooperative endeavor. Many thanks go to our colleagues of the Noble Metal Forum in Germany for their support: Prof. Dr. Kerstin Leopold (Institute of Analytical and Bioanalytical Chemistry, University of Ulm, Germany), Prof. Dr. Michael Schuster (Analytical Chemistry, Technische Universität München, Germany), Dr. Rudolf Schierl (Institute and Outpatient Clinic for Occupational, Social and Environmental Medicine, University Hospital of Munich, Germany), Prof. Dr. Stephan Hann (Department of Chemistry, University of Natural Resources and Life Sciences—BOKU Vienna, Austria) and Prof. Dr. Bernd Sures, Dr. Sonja Zimmermann und Dr. Nadine Ruchter (Aquatic Ecology and Centre for Water and Environmental Research, University of Duisburg-Essen, Germany).

In addition, special thanks go to Prof. Dr. Sebastien Rauch (Department of Civil and Environmental Engineering, Chalmers University of Technology, Sweden), Prof. Dr. Rumyana Djingova (Faculty of Chemistry and Parmacy University of Sofia, Bulgaria), Prof Dr. Vojtech Adam (Department of Chemistry and Biochemistry Faculty of Agronomy, Mendel University in Brno, Czech Republic), Prof. Dr. Ana Maria G. Figueiredo (Instituto de Pesquisas Energéticas e Nucleares, São Paulo, Brazil), Prof. Dr. Ivo Iavicoli (Institute of Public Health—Section of Occupational Medicine Università Cattolica del Sacro Cuore, Italy), Prof. Dr. Beata Godlewska-Żyłkiewicz (University of Bialystok, Institute of Chemistry, Poland), Prof. Dr. Krystyna Pyrzynska (Warsaw University, Chemistry Dept. Laboratory of Flow Analysis and Chromatography, Warsaw, Poland), Prof. Dr. Shankararaman Chellam (Department of Civil and Environmental Engineering, University of

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