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A MINI-REVIEW ON CURRENT TRENDS IN NOBLE GAS CHEMISTRY: FROM COMPOUNDS TO MEDICAL APPLICATIONS

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ABSTRACT

Noble gases which were traditionally termed as chemically inert, are now the focus of groundbreaking research in various sectors of chemistry, environmental science, medicine, and industrial applications. This mini-review explores the recent advancements and shines a spotlight on the synthesis of noble gas compounds, high-pressure chemical interactions, and improved measurement techniques for isotopic analysis. Key developments include their role in understanding Earth's mantle dynamics, the use of novel technologies for real-time environmental monitoring, and industrial innovations in gas separation. Furthermore, noble gases have shown potential in therapeutics, particularly in neuroprotection. These discoveries underscore the expanding utility of noble gases, paving the way for transformative insights and technologies across diverse fields.

KEYWORDS: Noble gases, Synthesis of noble gas compounds, Isotopic analysis, Environmental monitoring, Neuroprotection.

INTRODUCTION

Noble gases, long considered inert and chemically unreactive, have seen a surge of interest across various scientific disciplines due to advancements in analytical techniques and novel applications. These elements, which include helium, neon, argon, krypton, xenon, and radon, are now recognized for their unique chemical interactions, environmental relevance, and medical potential. Recent breakthroughs in noble gas chemistry have expanded our understanding of their behavior under diverse conditions, enabling applications in geoscience, industrial processes, environmental monitoring, and therapeutic interventions. This mini-review highlights current trends in noble gas research, emphasizing significant developments, novel applications, and the implications for future exploration.

Advances in Noble Gas Chemistry

Significant progress has been made in chemistry, physics, medicine, and environmental research as a result of recent developments in the realm of noble gases. According to Mazej (2020), who examined the synthesis and characterisation of noble-gas compounds published in the previous five years with an emphasis on works published after 2017[1], one noteworthy development is the growing interest in noble-gas compounds. It focused on studying helium droplets doped with atoms and molecules, helium surrounding monoatomic ions, and the interaction between ions of biological importance and noble gas atoms. The reaction between double-charged cations and noble atoms also resulted in the formation of a link between the noble gases. This indicates a growing exploration of the chemical properties and potential applications of noble gases beyond their traditional inert nature.

Ng et al. (2023) elevated the possibilities for understanding climate parameters by introducing a new large-volume equilibration method for accurate measurements of dissolved noble gas stable isotopes. The development of crystal structure search techniques has accelerated the study of noble gas chemistry in solid compounds at high pressure, resulting in the synthesis and prediction of new noble gas compounds. Noble gases show a variety of chemical forms and interactions at high pressure, such as covalent bonds between noble gas atoms, hydrogen bond-like noble gas bonds, and cationic and anionic forms. This development in measuring methods broadens our understanding of noble gas behavior in different surroundings, such seawater, and improves our comprehension of noble gas thermodynamic processes.[2] The solubility equilibrium isotope effects of noble gases in water were also covered by Seltzer (2023), who emphasized the developments in analytical techniques that have made it possible to measure these effects with high precision. This helps to clarify how noble gases interact with water, taking salinity and temperature into account to better understand environmental processes involving noble gases.[3]

Mukhopadhyay & Parai (2019) focused on the geological setting and emphasized the role of noble gases in understanding Earth's evolution and mantle dynamics. Noble gases are useful tracers for researching the mantle structure, long-term degassing processes, and the source of Earth's volatiles. This illustrates how important noble gases are to improving our knowledge of Earth's geological past.[4]

In 2024, Bachetzky conducted research on the adsorption of xenon, krypton, and their mixture on a metal–organic framework. This study highlights the growing significance of noble gases in both scientific and practical contexts. The present research emphasizes how noble gases can be used for a wide range of purposes outside of their conventional usage, suggesting new applications for these elements in different domains.[5]

The development of NUV-sensitive silicon photomultiplier technologies for scientific research employing liquid noble gases such as argon and xenon was also covered by Gola et al. (2019). This technical development represents a move toward increasingly sensitive and effective detection techniques, improving the potential of noble gas scintillator-based investigations.[6] Furthermore, the gas-equilibrium membrane-inlet portable mass spectrometer (GE-MIMS) was presented by Schilling et al. (2021) and enables real-time on-site analysis of dissolved noble gases in air and water.[7] By overcoming earlier restrictions on the temporal and spatial coverage of noble gas investigations, this breakthrough provides a more thorough understanding of the dynamics of noble gases in a variety of environmental systems.

A possible therapeutic role for noble gases in treating brain injuries was indicated by Yin et al. (2022) in the medical field, who also noted the growing interest in noble gases for neuroprotection. This newly emerging field of study highlights the various uses of noble gases outside of conventional scientific fields, suggesting their potential for improvements in medicine.[8]

Moreover, simulated screening of nanoporous materials for noble gas separation was carried out by Wang et al. (2022), highlighting the critical industrial uses of noble gases in areas like cryogenics and optical devices.[9] The efficiency of noble gas separation operations is improved by this research, which is important for many industrial processes that depend on these components.

CONCLUSION

In conclusion, recent developments in noble gases have greatly increased our knowledge of the characteristics and uses of these elements in a variety of fields. Noble gases are still vital to the advancement of research and technology, opening the door for fascinating new discoveries in fields ranging from chemistry to medicine to environmental science.

Conflict-of-Interest: Nil

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