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Editorial

Organometallic Science: From Fundamental Chemistry to a Cornerstone of Modern Innovations and Technological Advances

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1. Introduction

Nature created organometallic chemistry with the cobalt-carbon bond of vitamin B_{12} millions of years ago. Nowadays, organometallic compounds and reaction intermediates form the backbone of countless technological advances that shape our modern world [1]. From catalysis and materials science to nanotechnology [2–7], organometallic chemistry lies at the heart of innovations that impact energy production [8–10], sustainable practices [5,6,11–13] including CO_2 conversion [14–18] and utilization, and medical therapies [19–25]. As the field continues to evolve from its hard core, including the role of key ligands in catalysis [26–34] and energy storage [35–38], so too does its capacity to address pressing global challenges, including climate change, sustainable resource management, and the development of advanced functional materials.

Organometallic Science serves as an international platform dedicated to disseminating high-impact research and forward-looking perspectives that drive the discipline into new scientific and technological frontiers. By fostering a deeper understanding of organometallic compounds and nanocompounds and their multifaceted applications, the journal is committed to shaping the future of the field and inspiring the next generation of chemists and interdisciplinary researchers. ***Organometallic Science*** will publish communications, full research articles, perspective articles, account articles and comprehensive review articles, enhancing innovative findings and global awareness of the importance and relevance of organometallic chemistry and guiding the field towards the future, enabling multidisciplinary researchers to stay at the forefront of new developments.

2. The Role of Organometallic Chemistry in Modern Innovation

The profound impact of organometallic chemistry on modern science and technology cannot be overstated. Organometallic compounds, which feature metal-carbon bonds, have demonstrated unparalleled versatility and functionality, positioning them as essential components in a wide array of applications. From the synthesis of complex organic molecules to the development of advanced materials with tunable properties, organometallic chemistry has been a crucial contributor to contemporary scientific endeavors.

Furthermore, as the global community increasingly prioritizes sustainable and efficient technologies, organometallic chemistry offers unique solutions through catalytic transformations, renewable energy systems, and the creation of multifunctional materials. These advances are not only essential for technological innovation but also for addressing environmental and societal challenges.

By bridging the gap between fundamental research and practical applications, organometallic chemistry continues to shape industries as diverse as pharmaceuticals, energy, environmental science, and electronics. The interdisciplinary nature of the field highlights its importance and calls for continued exploration and innovation.

3. Advanced Materials and Nanotechnology

The versatility of organometallic compounds makes them indispensable in the development of advanced materials with tailored properties. These materials find applications in electronics, photonics, energy conversion, catalysis, nanomedicine and functional devices, where the unique electronic and structural characteristics of organometallic compounds enable groundbreaking performance.

In the realm of nanotechnology, organometallic compounds contribute to the synthesis of nanomaterials with remarkable precision and functionality. Organometallic polymers [12,13,36–38], metal-organic frameworks (MOFs) [16,36], carbon nanodots (CNDs) [39], graphene-based systems [40], and metal-containing dendrimers [24] are just a few examples of how these compounds are shaping the next generation of nanoscale devices and materials.

In energy applications, for example, organometallic systems facilitate catalytic processes that enable efficient hydrogen production and storage, as well as carbon capture [5] and conversion [14–18]. Meanwhile, in the realm of electronics and photonics, metal-containing polymers [6,11–13] and nanocomposites offer promising avenues for developing flexible electronics and optoelectronic devices.

As the need for advanced, multifunctional materials grows, the field of organometallic chemistry will continue to play a critical role in creating solutions that meet modern technological demands.

4. Catalysis: A Driving Force of Green and Sustainable Chemistry

Catalysis is undeniably one of the most impactful domains of organometallic chemistry, profoundly influencing both industrial and academic research. Organometallic catalysts enable the transformation of simple molecules into complex products with remarkable efficiency and selectivity [1]. These catalysts, whether operating in homogeneous or heterogeneous systems [3], are fundamental to processes that minimize energy consumption and reduce environmental footprints [5,6].

The development of organometallic catalysts has advanced significantly, driven by a desire to achieve greater activity, stability, and recyclability. Researchers are now designing catalysts that not only exhibit high efficiency but also align with the principles of green chemistry [5,6,35]. Examples include catalysts for carbon dioxide fixation [14–18], catalysts for water splitting [41,42], hydrogenation reaction [6,7] under mild conditions, and the selective functionalization of hydrocarbons[8].

Moreover, mechanistic studies and computational analyses have deepened our understanding of catalytic cycles, enabling the rational design of novel catalysts with enhanced performance. As the chemical industry seeks more sustainable solutions, organometallic catalysis will continue to be a crucial to innovation.

Recent advances in organometallic catalysts with nanomaterial supports have led to the science of nanoparticle catalysis or nanocatalysis [15]. Organometallic metal-organic frameworks (MOFs) [36,38] have emerged as versatile catalysts, combining the structural tunability of organic linkers with the catalytic activity of metal centers to facilitate a wide range of chemical transformations with high efficiency and selectivity. Innovations such as N-heterocyclic carbene (NHC)-stabilized metal nanoparticles [26,31–34], metal clusters on supports [30,43], and organometallic framework-derived nanomaterials [36,38,44] have demonstrated exceptional catalytic performance in processes like selective hydrogenation [7], C–C coupling [2], and CO_2 conversion [32]. These breakthroughs are enabling the design of multifunctional catalysts wcarbonyl

ith enhanced stability, selectivity, and recyclability, driving progress in sustainable chemical transformations and advanced material applications.

5. Medicinal Chemistry and Biomedical Applications

Organometallic chemistry holds tremendous potential in the realm of 30

chemistry, where metal-containing complexes offer unique therapeutic properties [23]. Transition metals, for instance, can stabilize reactive intermediates or facilitate ligand exchange reactions, leading to the design of drugs with novel mechanisms of action.

Research in this area is particularly focused on developing metal-based anticancer agents, antimicrobial compounds, and imaging probes. Platinum-based chemotherapeutics, such as cisplatin and its derivatives, have long been used in cancer treatment [19], while new metal-based agents continue to be investigated for their potential to target disease pathways with improved efficacy and reduced toxicity [19–24]. Ferrocenyl compounds and their derivatives have been investigated as promising candidates for cancer therapy, leveraging the unique redox properties of the ferrocene core to induce oxidative stress by the Fenton reaction and disrupt cellular function, while their versatile structural modification enables targeted drug design and enhanced therapeutic efficacy [20–24].

The application of organometallic compounds in diagnostics and targeted drug delivery is also expanding. Metallodrugs and coordination complexes offer unique opportunities for selective action and controlled release, making them promising candidates in the fight against cancer and infectious diseases [24].

6. Theoretical and Computational Approaches

The integration of theoretical and computational methods with experimental research is revolutionizing organometallic chemistry including monometallic [45,46] and cluster complexes [47,48]. By employing chemistry libraries [49], computational chemistry [50,51], and machine learning algorithms [52], researchers will be able model complex reactions, predict catalyst performance, and simulate molecular interactions with unprecedented accuracy.

The ability to rationalize experimental observations through density functional theory (DFT) calculations, molecular dynamics simulations, and data-driven predictions enables a deeper understanding of bonding, electronic structures, and reaction pathways [27,45–48]. Furthermore, the adoption of artificial intelligence in organometallic research will accelerate discoveries by identifying patterns and predicting optimal synthetic routes [52].

As computational power continues to grow, the synergy between theoretical models and experimental validation will remain vital to pushing the boundaries of organometallic chemistry.

7. The Future of Organometallic Chemistry

Looking ahead, the field of organometallic chemistry will play a crucial role in addressing the scientific and technological challenges of the 21st century. By integrating fundamental insights with innovative applications, ***Organometallic Science*** will continue to shape sustainable practices, medical breakthroughs, and the development of advanced materials.

Organometallic Science provides a modern platform for showcasing groundbreaking research. We encourage contributions that challenge conventional paradigms, explore novel methodologies, and demonstrate the transformative potential of organometallic systems. As the field continues to expand and diversify, our journal will remain at the forefront, guiding the global scientific community toward new horizons.

Conflicts of Interest

The authors declare no conflict of interest.

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