SCOPE OF ORGANOMETALLIC COMPLEXES WITH PROMISING THERAPEUTIC CAPABILITIES

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ABSTRACT

This paper explores the medicinal uses, chemical properties, and methods of synthesis of organometallic compounds, highlighting their potential as therapeutic agents and their diverse reactivity. These compounds play a crucial role in treating diseases and metabolic disorders, with metal structures playing a kinetic role at the cellular level. The text emphasises the synthesis, mechanisms of action, and many therapeutic applications of these compounds, with a specific focus on their usage as anticancer agents, antibacterial agents, and in targeted drug administration. It seeks to investigate the wide array of organometallic compounds utilised in medicine, elucidating their methods of action as well as their present and prospective applications in the treatment of numerous ailments. This review seeks to offer a comprehensive examination of the therapeutic applications of organometallic compounds, encompassing their modes of operation, present uses, and potential advancements in the fields of drug development and treatment. However, the development of antiviral drugs cannot solely rely on organometallic complexes. Challenges include potential toxicity and the complexity of synthesis and characterization, which require specialized equipment and expertise.

KEYWORDS: Organometallic compounds; Synthesis; Physiological; Medicinal; Biological activity

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1. INTRODUCTION

Organometallic compounds, comprising a metal atom or ion linked to one or more carbon atoms, have garnered considerable interest in medicinal chemistry for their distinctive characteristics and potential therapeutic advantages [1, 2]. The study of metal in medicine has shown its vital role in treating diseases and metabolic disorders. Inorganic chemistry, including iron-based drugs and metal detection agents, plays a significant role in understanding and treating diseases [2]. The study of iron, zinc, and copper has led to the development of diagnostic and therapeutic components for various diseases. Metal structures play a kinetic role at the cellular level in life processes. In the realm of cancer treatment, platinum-based organometallic compounds, for example, cisplatin, a platinum-based organometallic compound, have demonstrated remarkable success in inhibiting tumour growth in cancer treatment [2, 3]. Another example is ferrocene-based compounds, which have shown promise in stopping the replication of viruses, making them possible candidates for the development of antiviral drugs [3]. Including specific examples will enhance the reader's understanding of the potential applications of organometallic compounds in medicine. For instance, cisplatin has been widely used in the treatment of testicular, ovarian, and lung cancers, where it acts by binding to DNA and preventing cell division [3, 4]. This unique mechanism of action has made cisplatin a cornerstone in chemotherapy regimens for these types of cancer. Similarly, ferrocene-based compounds have shown potential for inhibiting the replication of HIV, offering a new avenue for the development of effective antiretroviral therapies [4].

This makes them possible candidates for the development of antiviral drugs. In the fight against bacterial infections, organometallic complexes of silver and gold have demonstrated potent antibacterial activity [5]. Some organometallic compounds exert their effects through DNA binding and interactions, leading to the inhibition of tumour growth. Others may inhibit specific enzymes involved in viral replication, preventing the spread of the virus [6]. Reactive oxygen species (ROS) generation is an additional mechanism by which certain organometallic compounds induce cell death in cancer cells [7]. However, it is important to note that the development of antiviral drugs cannot solely rely on the use of organometallic complexes. For example, HIV, a viral infection that affects millions of people worldwide, has proven to be highly resistant to organometallic compounds [8]. This highlights the need for alternative approaches in the development of antiviral drugs. While organometallic compounds show promise as therapeutic agents, there are challenges to consider. One limitation is the potential toxicity of these compounds, which may cause adverse side effects in patients. Additionally, the synthesis and characterization of organometallic compounds can be complex and time-consuming, requiring specialised equipment and expertise [9]. These challenges need to be addressed in order to fully harness the potential of organometallic compounds in medicine.

2. CHEMICAL PROPERTIES

2.1. *Bonding and structure*

Organometallic compounds are composed of a metal atom or ion that is bonded to one or more carbon atoms. The metal-carbon bond in organometallic compounds can be either covalent or ionic in nature, depending on the electronegativity difference between the metal and carbon atoms [10]. The presence of d-orbitals in the metal atom allows for the formation of coordination complexes, and the coordination number of the metal can vary. The bonding and structure of organometallic compounds play a crucial role in their chemical properties. The covalent or ionic nature of the metal-carbon bond determines the stability and reactivity of the compound. The presence of d-orbitals in the metal atom allows for the formation of coordination complexes, where the metal can coordinate with other ligands. This coordination number can vary and greatly impact the compound's properties and potential applications in medicine [11].

2.2. *Reactivity*

Organometallic compounds exhibit a wide range of reactivity due to the presence of both metal and organic components. They can undergo various types of reactions, including substitution, addition, elimination, and oxidative addition/reductive elimination reactions. The reactivity of organometallic compounds can be influenced by factors such as the nature of the metal, the ligands attached to the metal, and the presence of functional groups on the organic moiety [12]. As an example, an organometallic compound based on platinum that has ligands with nitrogen atoms may be very reactive towards nucleophilic substitution reactions. This reactivity can be increased even more by adding functional groups that remove electrons from the organic moiety. This lets only certain parts of a molecule are changed. In medicine, this reactivity can be harnessed to design targeted drug delivery systems

that release therapeutic agents only at specific locations within the body, minimising side effects and improving treatment efficacy [13].

2.3. *Ligand exchange*

Organometallic compounds have the ability to undergo ligand exchange reactions, in which one or more ligands that are bound to the metal are substituted with different ligands. The ligand exchange processes can be affected by various parameters, including the electronic and steric characteristics of the ligands and the properties of the metal centre [14]. Ligand exchange reactions play a crucial role in the synthesis and modification of organometallic compounds, allowing for the introduction of desired functional groups or ligands. For instance, ligand exchange reactions can be used to change the metal's ligands to ones that have the right electronic and steric properties when making a new organometallic catalyst. This allows for the tuning of the catalyst's reactivity and selectivity, resulting in improved catalytic performance [15].

2.4. *Redox chemistry*

The redox properties of organometallic compounds are influenced by the electronic properties of the metal center and the ligands attached to it. For example, in the field of hydrogenation, a catalytic process used in the production of chemicals and fuels, organometallic compounds can be used as catalysts. These compounds can undergo redox reactions, where they transfer electrons between the metal center and the organic moiety. Researchers can change the redox properties of the catalyst by carefully choosing the metal centre and the ligands that are attached to it. This makes hydrogenation reactions more reactive and selective. This enables more efficient and selective conversion of organic compounds into desired products [16]. Additionally, the metal-ligand interactions can also influence the stability and durability of the catalyst, leading to longer catalyst lifetimes and reduced costs. Furthermore, the use of organometallic catalysts in hydrogenation reactions offers a greener alternative to traditional methods, as they often operate under milder reaction conditions and produce less waste. Overall, the design and optimization of organometallic catalysts play a crucial role in advancing the field of hydrogenation and facilitating sustainable chemical synthesis [17, 18].

2.5. *Stability and decomposition*

The stability of organometallic compounds is contingent upon various elements, including the metal's composition, the ligands bound to it, and the conditions under which the reaction occurs. Some organometallic compounds are highly stable and can withstand a wide range of reaction conditions, while others may be sensitive to air, moisture, or heat. Decomposition of organometallic compounds can occur through various pathways, including ligand dissociation, metal-ligand bond cleavage, or reaction with external reagents. Understanding the chemical properties of organometallic compounds is crucial for their synthesis, characterization, and application in various fields, including catalysis, materials science, and medicinal chemistry. Continued study in this field will enhance our understanding and facilitate the creation of novel organometallic compounds that possess customised characteristics and practical uses [17].

3. METHODS OF SYNTHESIS

Organometallic compounds, which contain at least one metal-carbon bond, play a crucial role in various fields such as catalysis, materials science, and medicinal chemistry. The synthesis of these compounds involves the formation of metal-carbon bonds through different methods. This scientific note provides an overview of the commonly employed methods for the synthesis of organometallic compounds.

3.1. *Metal-halogen exchange*

In this method, a metal halide compound reacts with an organometallic reagent containing a metal-carbon bond. The metal-halogen bond is cleaved, and a new metal-carbon bond is formed. Commonly used reagents include Grignard reagents and organolithium compounds.

3.2 *Metal-reduction of metal salts*

Metal salts, such as metal halides or metal oxides, can be reduced by alkali metals or other reducing agents. The reduction process leads to the formation of metal atoms or ions, which can then react with organic compounds to form organometallic compounds.

3.3 *Insertion reactions*

3.3.1. *Oxidative addition*

This method involves the reaction of a metal species with a suitable organic compound, typically a halide or hydrogen. The metal species undergoes oxidative addition, resulting in the formation of a new metal-carbon bond. Commonly used metals for oxidative addition

reactions include palladium, platinum, and nickel. For example, in the synthesis of organic compounds using oxidative addition, a palladium catalyst is used to react with a halide compound. The palladium species undergoes oxidative addition, forming a new bond between the metal and carbon atoms in the halide compound. This reaction is commonly used in cross-coupling reactions, where two different organic compounds are combined to form a more complex molecule [18, 19].

3.3.2. *Carbometalation*

Carbometalation involves the addition of a metal species to a carbon-carbon multiple bond, such as an alkene or alkyne. The metal species inserts itself into the carbon-carbon bond, leading to the formation of a new metal-carbon bond [20, 21]. For example, in a carbometalation reaction, a palladium catalyst can be used to react with an alkene. The palladium species inserts itself into the carbon-carbon double bond, forming a new bond between the metal and carbon atoms. This reaction allows for the synthesis of more complex organic molecules by introducing a metal species into the carbon-carbon multiple bonds [22, 23].

3.4. *Ligand exchange reactions*

- Ligand exchange reactions involve the substitution of one ligand in a metal complex with an organometallic reagent.
- The reaction can occur through various mechanisms, such as associative or dissociative ligand exchange.
- Commonly used ligands for exchange reactions include carbon monoxide (CO), phosphines, and alkyl or aryl groups.

3.5. *Other methods*

3.5.1. *Transmetalation*

Transmetalation involves the transfer of a metal ligand from one metal center to another. This method is often used in the synthesis of complex organometallic compounds. For example, in the synthesis of a complex organometallic compound, transmetalation can be used to transfer a ligand from one metal center to another. This process allows for the creation of a new metal-ligand bond and can result in the formation of unique and intricate structures [23].

3.5.2. *Metathesis*

Metathesis reactions involve the exchange of ligands between two metal complexes. This method is commonly used in the synthesis of olefin metathesis catalysts. For example, in the synthesis of an olefin metathesis catalyst, metathesis reactions can be employed to exchange ligands between two metal complexes. This process makes it possible to make catalysts with specific arrangements of ligands, which improves the activity and selectivity of the catalysts in olefin metathesis reactions.

4. MEDICINAL APPLICATIONS

Organometallic compounds have garnered considerable interest in the field of medicine in recent years, owing to their distinctive characteristics and potential for therapeutic use. This section explores the various medicinal applications of organometallic compounds, including their use as anticancer agents, antiviral agents, antibacterial agents, antifungal agents, and more are shown in Table 1.

TABLE 1. Organometallic compounds and their biomedicinal potential use [24]

S. No.	Organometallic Drugs	Uses
(i)	Carboplatin	used to treat advanced ovarian cancer
(ii)	Ferric oxyhydroxide	Used for the treatment of hyperphosphatemia
iii)	Sucralfate	Used for the management of gastric and duodenal ulcers and for the prevention of duodenal ulcer recurrence
iv)	Technetium Tc-99m arcitumomab	For imaging colorectal tumors
(v)	Chlormerodrin	Used as a diuretic
vi)	Auranofin	Used for the treatment of inflammatory arthritis
vii)	Picoplatin	For the treatment of patients with solid tumors
viii)	AP5346	For the treatment of various forms of cancer
ix)	Satraplatin	Used for potential application in lung cancer, prostate cancer, and solid tumours
(x)	AP5280	Investigated for use/treatment in solid tumors
xi)	Aurothioglucose	A gold compound used in the treatment of rheumatoid arthritis
xii)	Technetium Tc-99m mebrofenin	A diagnostic radiopharmaceutical agent used during

		hepatobiliary imaging tests
xiii)	Mersalyl	Elevated blood pressure, edema
xiv)	Thimerosal	Used as a preservative in certain cosmetics, topical pharmaceuticals, and biological drug products, including vaccines
xv)	Lobaplatin	Utilised in clinical trials investigating the therapeutic approaches for Breast Cancer, Hepatocellular Carcinoma, and the combined administration of Lobaplatin and Gemcitabine
xvi)	Nedaplatin	Used in the treatment of non-small cell lung cancer, small cell lung cancer, oesophygeal cancer, and head and neck cancers
xvii)	Merbromin	A topical antiseptic
viii)	Phenylmercuric acetate	used as a fungicide and slimicide

4.1 *Anticancer agents*

Anticancer agents are a class of drugs used in the treatment of cancer. They work by targeting and inhibiting the growth of cancer cells, either by directly killing them or by interfering with their ability to divide and multiply.

- **Platinum-Based Compounds:** Platinum-based anticancer agents, such as cisplatin and carboplatin, are widely used in chemotherapy. They form DNA adducts, leading to DNA damage and cell death. These compounds are effective against various types of cancer, including testicular, ovarian, and lung cancer [25, 26].

Platinum-based compounds have demonstrated efficacy against diverse forms of cancer, including testicular, ovarian, and lung cancer. However, they can also induce notable adverse effects such as nephrotoxicity and neurotoxicity. Ruthenium-based compounds, on the other hand, offer a different mechanism of action and have shown promise in preclinical studies, but further research is needed to optimize their efficacy and pharmacokinetic properties. Similarly, organometallic antiviral agents have demonstrated activity against a wide range of viruses, but challenges remain in understanding their mechanisms of action and optimizing their selectivity [27].

- **Ruthenium-Based Compounds:** Ruthenium-based anticancer agents, such as NAMI-A and KP1019, have shown promising results in preclinical studies. They exhibit distinct mechanisms of action, such as suppressing tumour metastasis and triggering apoptosis in cancer cells [28, 29].
- **Mechanisms of Action:** Anticancer agents can act through various mechanisms, including DNA binding and interactions, enzyme inhibition, and the generation of reactive oxygen species (ROS). These mechanisms disrupt cancer cell growth and survival, leading to their destruction [30].

Organometallic compounds have shown promise in the treatment of conditions such as cancer, viral infections (including HIV and herpes simplex virus), bacterial infections, and fungal infections. For example, platinum-based compounds like cisplatin are widely used in chemotherapy for various types of cancer, while ferrocene-based antiviral agents have demonstrated activity against HIV, herpes simplex virus, and hepatitis B virus [31].

4.2 *Antiviral agents*

Organometallic compounds have shown promising potential as antiviral agents due to their unique properties and mechanisms of action.

- **Ferrocene**-based antiviral agents have demonstrated activity against a wide range of viruses, including HIV, herpes simplex virus (HSV), and hepatitis B virus (HBV).

The mechanism of action of ferrocene-based antiviral agents involves inhibition of viral replication by interfering with viral enzymes or viral protein synthesis.

- **Rhodium**-Another class of organometallic antiviral agents includes rhodium-based compounds. Rhodium complexes have shown potent antiviral activity against HIV and other retroviruses.

Rhodium based antiviral agents inhibit viral replication by binding to viral RNA and preventing its proper function in viral replication and protein synthesis [32].

4.3 *Antibacterial agents*

Organometallic antibacterial agents are a burgeoning class of compounds that have garnered significant attention in recent years for their potential in combating bacterial infections. These agents are made up of organic ligands mixed with transition metal atoms. They have new ways of killing microbes and special properties that have never been seen before in antimicrobial research.

Organometallic antibacterial agents typically comprise organic ligands coordinated to one or more transition metal ions. The choice of metal and ligand types greatly influences the chemical and biological properties of these compounds. Common transition metals used include silver, gold, copper, and platinum, among others. The organic ligands can vary in size, shape, and functionality, allowing for fine-tuning of their antimicrobial activity [33].

4.4 *Antifungal agents*

Organometallic antifungal agents represent a unique and emerging class of compounds that have shown promise in the field of antifungal research. These compounds combine organic ligands with transition metal atoms to create novel molecules with potent antifungal properties. This scientific note explores the key aspects of organometallic antifungal agents [33, 34].

- **Composition and Structure:** Organometallic antifungal agents typically consist of organic ligands coordinated to one or more transition metal ions. The choice of metals and ligands can be varied, affecting the compound's chemical and biological properties. Common transition metals used in these agents include ruthenium, gold, and silver, among others. The organic ligands can be designed to optimise their antifungal activity [34].
- **Broad-Spectrum Activity**: Organometallic antifungal agents have demonstrated effectiveness against a wide range of fungal species, including drug-resistant strains. Their versatility in targeting different types of fungi makes them valuable in the treatment of fungal infections that are difficult to manage with conventional antifungal agents.

5. MECHANISMS OF ACTION

Organometallic compounds can exhibit various mechanisms of action when used for medicinal purposes, depending on their specific structures and applications. These mechanisms of action can contribute to their medicinal activity in diverse ways. Here are some common mechanisms of action for organometallic compounds in medicinal applications:

- **Catalytic reactions:** Some organometallic compounds can serve as catalysts in enzymatic reactions, promoting or accelerating specific chemical transformations within the body. For example, metallocene compounds, like ferrocene derivatives, can mimic enzymatic reactions and catalyse reactions relevant to medicinal chemistry.
- **Metalloenzyme inhibition:** Certain organometallic compounds can act as inhibitors of metalloenzymes by binding to the metal ions in the enzyme's active site. This interaction can disrupt the enzyme's function and impact various physiological processes.
- **Targeting Reactive Oxygen Species (ROS):** Some organometallic complexes, such as metal-based antioxidant compounds, can neutralise reactive oxygen species (ROS) in the body. ROS are implicated in various diseases, and by quenching them, these compounds can have antioxidant and protective effects.
- **Drug delivery:** Organometallic compounds can be used as carriers or delivery vehicles for therapeutic agents. By forming stable complexes with drugs, they can improve drug solubility, bioavailability, and targeting of specific tissues or cells.
- **DNA Binding and modification:** Certain organometallic compounds can interact with DNA through coordination with the DNA bases or the phosphate backbone. This interaction can lead to DNA damage, inhibition of replication, or modulation of gene expression, which is relevant in anticancer and antiviral applications.
- **Metal-based medicines:** Some organometallic compounds have metal centers that can serve as essential components of medicines. For instance, cisplatin, a platinum-based organometallic compound, is widely used as a chemotherapeutic agent and works by cross-linking DNA, leading to cell death.
- **Anti-inflammatory activity:** Organometallic compounds can exhibit anti-inflammatory effects by modulating the activity of pro-inflammatory enzymes or pathways. For example, metallocenes have been investigated for their potential as anti-inflammatory agents.
- **Antimicrobial activity:** Organometallic compounds can disrupt microbial membranes, inhibit enzymes essential for microbial growth, or generate reactive oxygen species to exert antibacterial or antifungal effects.
- **Targeting specific proteins:** In some cases, organometallic compounds can be designed to selectively target specific proteins or receptors involved in diseases. This targeted approach is important in drug design for conditions like cancer and neurodegenerative disorders.
- **Radiopharmaceuticals:** Some organometallic compounds with radioactive isotopes can be used in nuclear medicine as radiopharmaceuticals for diagnostic and therapeutic purposes. These compounds can accumulate at specific sites in the body to treat diseases, such as cancer.

6. CURRENT AND FUTURE PERSPECTIVES

Organometallic compounds have emerged as a fascinating and versatile class of compounds with

promising applications in medicine. Current research and clinical developments highlight their multifaceted utility, including their synthesis, mechanisms of action, and diverse medicinal uses. Organometallic compounds in medicine have made significant strides, demonstrating their potential in areas such as cancer treatment, antimicrobial therapy, and targeted drug delivery. The future promises further refinement and expansion of these applications, with precision medicine and regulatory support paving the way for innovative and effective treatments. Organometallic compounds stand at the forefront of medical advancements, offering new hope for addressing complex and challenging diseases.

6.1 *Challenges and limitations*

Organometallic compounds used in medicine, while promising, are not without challenges and limitations. Two significant concerns are their potential toxicity and issues related to bioavailability. Here's an overview of these challenges and limitations:

6.1.1. *Toxicity*

- Organometallic compounds can be toxic, especially if they contain heavy metals or exhibit high reactivity. For example, some platinum-based organometallic compounds, like cisplatin, are known to cause nephrotoxicity and neurotoxicity [35].
- The toxicity of organometallic compounds can limit their therapeutic window, leading to dose-dependent side effects that may restrict their clinical use.
- Metabolism and biotransformation of organometallic compounds can generate toxic byproducts. This can complicate the assessment of their overall safety and toxicity profile.

6.1.2. *Bioavailability*

- Achieving optimal bioavailability is a challenge for many organometallic compounds, as their structure and reactivity can affect their absorption, distribution, metabolism, and excretion (ADME) in the body [35, 36].
- Poor water solubility is a common issue, making it challenging to formulate organometallic drugs in a way that ensures adequate delivery to the target site.
- Bioavailability issues can result in suboptimal drug concentrations at the target site, leading to reduced efficacy or the need for higher doses with potential toxicity concerns.

6.1.3. *Biodistribution and targeting*

- Organometallic compounds may have unpredictable biodistribution patterns, which can affect their ability to reach specific target tissues or cells.
- Achieving selective targeting, particularly for cancer therapy, remains a challenge. Many organometallic drugs have difficulty distinguishing between cancer cells and healthy cells, leading to off-target effects and toxicity. [36]

6.1.4. *Resistance and tolerance*

- Like any therapeutic agent, organometallic compounds can develop resistance or tolerance. Fungi or bacteria may develop resistance, while cancer cells can become resistant to metal-based chemotherapeutics.
- Continuous exposure to organometallic compounds can lead to acquired tolerance, limiting their long-term effectiveness.

6.1.5. *Regulatory hurdles*

Regulatory approval for new organometallic drugs can be a complex and lengthy process, as they require rigorous safety and efficacy evaluations. The specialised expertise and resources needed for this process can be substantial.

6.1.6. *Limited clinical experience*

The clinical experience with organometallic compounds as medicines is relatively limited compared to conventional small-molecule drugs. This lack of long-term data makes it challenging to fully understand their safety and efficacy profiles.

6.1.7. *High development costs*

The research, development, and production of organometallic drugs can be expensive, primarily due to the complexity of their synthesis and the need for specialised equipment and expertise.

In conclusion, the use of organometallic compounds as medicines presents significant challenges related to toxicity, bioavailability, targeting, resistance, regulatory hurdles, and high development costs. Addressing these challenges requires a combination of innovative research, formulation techniques, and regulatory cooperation to maximise the therapeutic potential of these compounds while minimising their limitations.

6.2 *Emerging trends and future directions*

Emerging trends and future directions in the use of organometallic compounds as medicines reflect ongoing advancements and research in this field. Here are some key areas of interest and potential developments:

- *Precision medicine*

In the future, organometallic medicine may place greater emphasis on precision medicine, which involves customising treatments based on an individual's genetic and molecular characteristics. This strategy can optimise treatment effectiveness while minimising the occurrence of adverse effects.

- *Multimodal therapies*

Combining organometallic compounds with other therapeutic agents, such as small molecules or biologics, is an emerging trend. This approach can create synergistic effects and address complex diseases more comprehensively.

- *Development of metallo-drug conjugates*

Metallo-drug conjugates, where an organometallic compound is linked to a biologically active molecule, are gaining attention. These conjugates can improve the selectivity of treatment and reduce off-target effects.

- *Enhanced drug design*

Rational drug design, computational modeling, and the development of novel ligands will continue to advance the creation of organometallic drugs with improved pharmacological properties, including increased bioavailability and reduced toxicity.

- *Personalized cancer therapy*

Organometallic compounds, particularly metal-based agents, will play a role in the evolution of personalised cancer therapy. By identifying individual patient profiles, clinicians can choose the most effective metal-based treatment based on a patient's specific cancer type and genetics.

- *Theranostics*

The development of theranostic agents, which can simultaneously diagnose and treat diseases, will likely expand. Organometallic compounds can be incorporated into imaging agents and therapeutic compounds to provide real-time monitoring of treatment effectiveness.

7. CONCLUSION

Organometallic compounds are a promising field in the medical field, with diverse applications in treating various diseases. Their unique properties and mechanisms of action make them invaluable tools in cancer treatment, antimicrobial therapy, and targeted drug delivery. The development of metallo-drug conjugates, theranostics, and radiopharmaceuticals highlights the versatility of organometallic compounds in diagnosing and treating various ailments. Advances in drug design, regulatory approval, and sustainable synthesis methods will shape the field’s evolution, ultimately leading to improved healthcare options for various diseases. Despite challenges such as toxicity and bioavailability, continuous research and inventive strategies are gradually surmounting these constraints. The future of organometallic compounds as medicines holds great potential, with emerging trends such as precision medicine, targeted drug delivery, and personalized therapies leading the way. Collaboration among researchers, regulatory agencies, and the pharmaceutical industry will be instrumental in realizing the full therapeutic potential of organometallic compounds, ultimately improving the health and well-being of patients worldwide. In conclusion, the medicinal use of organometallic compounds represents an exciting and evolving frontier in healthcare and pharmaceuticals. These substances, characterized by their distinct structures and diverse methods of action, have demonstrated considerable potential in treating several ailments, including cancer and microbial infections. However, the development of antiviral drugs cannot solely rely on organometallic complexes, as HIV is highly resistant to these compounds. Challenges include potential toxicity and the complexity of synthesis and characterization, which require specialized equipment and expertise.

DECLARATIONS

Conflict of interest

The authors have no pertinent financial or non-financial conflicts of interest to declare. The authors assert that there are no conflicts of interest pertaining to the publication of this article.

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