DIOXOMOLYBDENUM CLATHRATE COMPLEXES WITH LOW-MOLECULAR ORGANIC COMPOUNDS AND PHARMACEUTICAL PREPARATIONS

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Keywords: *dioxomolybdenum, clathrate complexes, coordination compounds, pharmaceutical substances, low-molecular organic compounds, drug delivery systems.*

Relevance. In recent years, the growing interest in coordination and supramolecular chemistry has significantly expanded the study of metal-based complexes with potential applications in pharmaceuticals and materials science. Among these, dioxomolybdenum (VI) compounds have attracted particular attention due to their structural diversity, stability, and biological relevance. As an essential trace element, molybdenum plays a key role in enzymatic processes, which increases the importance of investigating its coordination behavior with organic and biologically active molecules.

Clathrate complexes represent a special class of supramolecular systems characterized by the inclusion of guest molecules into a host framework without the formation of strong covalent bonds. This property allows modification of important physicochemical parameters such as solubility, stability, and reactivity. In pharmaceutical applications, such systems are

especially valuable, as they can improve the bioavailability of drugs, protect active substances from degradation, and enable controlled release.

However, despite the considerable progress in this field, the formation and properties of clathrate complexes based on dioxomolybdenum with low-molecular organic compounds and pharmaceutical substances remain insufficiently studied. Most research has focused on classical coordination compounds, while the supramolecular inclusion capabilities of dioxomolybdenum systems have not been fully explored. This creates a need for systematic investigation of their synthesis, structure, and functional properties.

Low-molecular organic ligands containing donor atoms such as nitrogen and oxygen can effectively coordinate with dioxomolybdenum and participate in the formation of stable supramolecular structures. Their combination with pharmaceutical compounds opens new possibilities for designing advanced functional systems with improved characteristics. In particular, such complexes may influence drug solubility, stability, and pharmacological efficiency.

Therefore, the study of dioxomolybdenum clathrate complexes with low-molecular organic compounds and pharmaceutical preparations is highly relevant. It contributes to the development of new approaches in drug delivery, enhances the understanding of supramolecular interactions, and supports the creation of innovative materials with potential biomedical applications.

The Purpose of the Study. The purpose of this study is to investigate the synthesis, structural features, and physicochemical properties of clathrate complexes formed by dioxomolybdenum (VI) with low-molecular organic compounds and selected pharmaceutical substances. Special attention is given to understanding the mechanisms of interaction between the metal center and organic ligands, as well as the inclusion behavior of drug molecules within the formed supramolecular systems.

The study also aims to determine how the formation of such clathrate complexes influences key properties of pharmaceutical compounds, including their solubility, stability, and potential bioavailability. In addition, it seeks to identify the role of donor atoms (such as nitrogen and oxygen) in stabilizing the complexes and promoting the formation of ordered structures.

Ultimately, the research is directed toward evaluating the potential application of these complexes in pharmaceutical chemistry, particularly in the development of improved drug delivery systems and multifunctional bioactive materials.

Research Materials and Methods. In this study, dioxomolybdenum (VI) compounds were used as the main metal source for the synthesis of clathrate complexes. As low-molecular organic ligands, compounds containing donor atoms such as nitrogen and oxygen (including amines, alcohols, and heterocyclic compounds) were selected. In addition, several pharmaceutical substances with known biological activity were included as guest molecules to investigate their interaction with the metal complexes.

The synthesis of clathrate complexes was carried out using conventional solution-based methods. Appropriate amounts of dioxomolybdenum precursor and organic ligands were dissolved in suitable solvents such as water, ethanol, or mixed solvent systems. The reaction mixtures were stirred under controlled temperature conditions, typically in the range of 25–80°C, for a defined period to ensure complete interaction. In some cases, slow evaporation or crystallization techniques were applied to obtain solid clathrate complexes.

The obtained compounds were isolated, purified, and subjected to comprehensive physicochemical characterization. Infrared (IR) spectroscopy was used to identify functional groups and confirm coordination between the metal center and ligands. UV-Vis spectroscopy was employed to study electronic transitions and complex formation. Thermal analysis methods,

including thermogravimetric analysis (TGA), were used to evaluate the thermal stability and decomposition behavior of the complexes.

Additionally, elemental analysis and, where possible, X-ray diffraction (XRD) techniques were applied to determine the composition and structural features of the synthesized compounds. The collected data were analyzed to establish the relationship between structure and properties, as well as to assess the formation of clathrate-type inclusion systems.

Results and Discussion. The conducted experiments demonstrated that dioxomolybdenum (VI) readily interacts with low-molecular organic compounds to form stable coordination systems, which in many cases exhibit clathrate-type inclusion properties. The synthesis procedures resulted in the successful formation of solid complexes with relatively high yields, indicating favorable conditions for complexation and supramolecular assembly.

Infrared (IR) spectroscopy analysis confirmed the coordination between the metal center and organic ligands through characteristic shifts in absorption bands corresponding to functional groups such as –NH, –OH, and C=O. In particular, the appearance of new bands associated with Mo=O stretching vibrations and changes in ligand-related frequencies provided evidence for the formation of coordination bonds. UV-Vis spectroscopy further supported complex formation by revealing changes in electronic transition patterns compared to the initial compounds.

Thermal analysis showed that the synthesized complexes possess moderate to high thermal stability, which is an important factor for their potential practical applications. The thermogravimetric data indicated stepwise decomposition processes, suggesting the presence of included (guest) molecules within the structure, which is characteristic of clathrate systems. This behavior supports the assumption that pharmaceutical substances can be successfully incorporated into the host framework.

The interaction of dioxomolybdenum complexes with pharmaceutical compounds revealed notable changes in physicochemical properties. In several cases, an increase in solubility and improved stability of the drug molecules were observed. These effects can be attributed to the formation of inclusion complexes, where the host structure protects the guest molecule from environmental factors such as oxidation or hydrolysis. Furthermore, the presence of hydrogen bonding and weak intermolecular interactions contributes to the stabilization of the overall system.

From a structural perspective, the participation of donor atoms such as nitrogen and oxygen played a crucial role in directing the formation of ordered supramolecular architectures. The obtained results suggest that ligand structure and functional groups significantly influence the geometry and stability of the complexes. This highlights the importance of rational ligand selection in the design of such systems.

Overall, the findings confirm that dioxomolybdenum (VI) complexes are capable of forming clathrate-type structures with low-molecular organic compounds and pharmaceutical substances. These systems exhibit promising characteristics that may be utilized in the development of advanced drug delivery systems and functional materials. However, further detailed structural and biological studies are required to fully evaluate their practical potential.

Conclusion. In this study, the synthesis and characterization of clathrate complexes based on dioxomolybdenum (VI) with low-molecular organic compounds and pharmaceutical substances were successfully carried out. The results demonstrated that dioxomolybdenum is capable of forming stable coordination and supramolecular systems through interactions with ligands containing donor atoms such as nitrogen and oxygen.

Spectroscopic and thermal analyses confirmed the formation of clathrate-type structures and revealed their notable stability and inclusion properties. The incorporation of pharmaceutical compounds into these

complexes was shown to influence their physicochemical characteristics, particularly improving solubility and stability, which are critical factors in drug effectiveness.

Overall, the obtained findings highlight the potential of dioxomolybdenum clathrate complexes as promising candidates for applications in pharmaceutical chemistry, especially in the development of advanced drug delivery systems. Further investigations focused on detailed structural analysis and biological activity are necessary to fully explore their practical applicability.

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