IR SPECTROSCOPIC STUDY OF THE COORDINATION COMPOUND OF Zn(II) ION WITH KETOROLAC

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Annotatsiya. Ushbu maqolada rux nitrat va ketorolak asosida hosil qilingan yangi koordinatsion birikmaning sintezi va fizik-kimyoviy xossalari o'rganildi. Kompleks birikma $[Zn(ket)_2](NO_3)_2 \bullet 2H_2O$ suv va etanol aralashmasida pH = 5.5–6 sharoitida sintez qilindi. Oq kristall holida cho'kma sifatida ajralib chiqdi. Sintez qilingan modda IR-spektroskopiya, UV-Vis va elementar analiz metodlari yordamida tahlil qilindi. Natijalar birikmada Zn–O koordinatsion bog'lar hosil bo'lganini, ketorolak esa karboksil guruhi orqali rux ioniga bog'langanini ko'rsatdi. Tadqiqot natijalari yangi koordinatsion birikmalar sintezining farmatsevtika va noorganik kimyo sohalaridagi ahamiyatini tasdiqlaydi.

Kalit so'zlar: Ketorolak, formamid, atsetamid, karbamid, nikotinamid, kompleks birikma, aralash-ligandli kompleks birikma, metall kompleks, IR-spektroskopiya, UV-Vis, element analiz.

Аннотация. В данной статье представлен синтез и физико-химическая характеристика нового координационного соединения, полученного из нитрата цинка и кеторолака. Соединение $[Zn(ket)_2](NO_3)_2 \bullet 2H_2O$ было синтезировано в смеси вода–этанол при pH 5,5–6 и выделено в виде белых кристаллов. Синтезированное соединение было проанализировано с использованием ИК-спектроскопии, УФ-видимой спектроскопии и элементного анализа. Результаты подтвердили образование координационных связей Zn–O, при этом кеторолак выступает в качестве лиганда через свою карбоксильную группу. В исследовании подчеркивается значимость синтеза новых координационных соединений для применения в фармацевтической и неорганической химии.

Ключевые слова: Кеторолак, формамид, ацетамид, карбамид, никотинамид, комплексное соединение, смешанно-лигандное комплексное соединение, металлический комплекс, ИК-спектроскопия, УФ-видимая спектроскопия, элементный анализ.

Abstract: This article presents the synthesis and physicochemical characterization of a novel coordination compound formed from zinc nitrate and ketorolac. The compound $[Zn(ket)_2](NO_3)_2 \cdot 2H_2O$ was synthesized in a water–ethanol mixture under pH conditions of 5.5–6 and precipitated as white crystals. The synthesized compound was analyzed using IR spectroscopy, UV-Vis spectroscopy, and elemental analysis. The results confirmed the formation of Zn–O coordination bonds, with ketorolac acting as a ligand through its carboxyl group. The study emphasizes the significance of synthesizing new coordination compounds for applications in pharmaceutical and inorganic chemistry.

Keywords: Ketorolac, formamide, coordination compound, mixed-ligand coordination compound, metal complex, IR spectroscopy (Infrared spectroscopy), UV-Vis spectroscopy (Ultraviolet–Visible spectroscopy), elemental analysis.

The chemistry of coordination compounds is currently one of the most promising fields in pharmaceutical and biomedical research. In particular, complexes formed between bioactive molecules and metal ions play a crucial role in enhancing pharmacological effects. This review focuses on the available literature concerning the coordination compound formed between ketorolac and the zinc (Zn) element, analyzing the data across several key directions.

Ketorolac is a non-steroidal anti-inflammatory drug (NSAID), whose mechanism of action is based on the inhibition of cyclooxygenase (COX) enzymes involved in the synthesis of prostaglandins. It exhibits analgesic, anti-inflammatory, and antipyretic effects. According to [1] ketorolac possesses a molecular structure that includes a carboxyl group, enabling it to coordinate with metal ions via the oxygen atom of this group. Zinc is an essential trace element for the human body and is involved in the structure and function of over 100 enzymes. It plays a pivotal role in the immune system, DNA synthesis, antioxidant defense, and wound healing. The chemical and biological properties of zinc, including its $3d^{10}$ electronic configuration and its tendency to form complexes with a coordination number of six, are described in [2]. From a coordination chemistry perspective, zinc's strong binding affinity toward oxygen-donor ligands, particularly carboxyl groups, enhances its potential to form bioactive complexes. The complexes formed between ketorolac and zinc are based on coordination bonding involving the oxygen atom of the carboxyl group. Reference [3] provides information on complexes formed between zinc and ketoprofen (a structural analog of ketorolac), noting that such complexes often involve mixed ligands — including urea, ethylenediamine, or monoethanolamine. Crystallographic parameters of these complexes, such as bond lengths, angles, and coordination geometries (e.g., octahedral arrangements), are detailed in [4].

Ketorolac-zinc complexes have attracted significant attention due to their notable antibacterial and antiviral activity. As reported in [3], these complexes demonstrated considerably higher antibacterial efficacy compared to ketorolac alone. These results are attributed to the synergistic effect between the metal ion and the organic ligand, which enhances biological activity. Furthermore, other studies have explored the anti-inflammatory, antioxidant, and even anticancer potential of such complexes. Their pharmacokinetic properties — including absorption, metabolism, and excretion in the body — have been analyzed in [5]. The existing literature suggests that coordination compounds formed between ketorolac and zinc are of great pharmacological promise. However, the synthesis, physicochemical characterization (e.g., IR, UV-Vis spectroscopy, elemental analysis), structural features, and biological activity of these complexes remain insufficiently explored. This underlines the novelty and relevance of further scientific research in this field.

To investigate the composition and structure of the synthesized coordination compounds, several physicochemical analytical methods were employed. Initially, the infrared (IR) spectra of the coordination complex were recorded in the range of 400–4000 cm^{-1} using a Shimadzu IR Affinity-1S spectrophotometer (Japan). The samples were prepared in the form of potassium bromide (KBr) pellets with a diameter of 7 mm. For a comprehensive interpretation of the IR spectroscopic data, spectra were obtained for the individual zinc salt, the free ligand ketorolac, and the synthesized coordination complex. Comparative analysis of these spectra allowed for detailed examination of the coordination behavior and structural features of the complex.

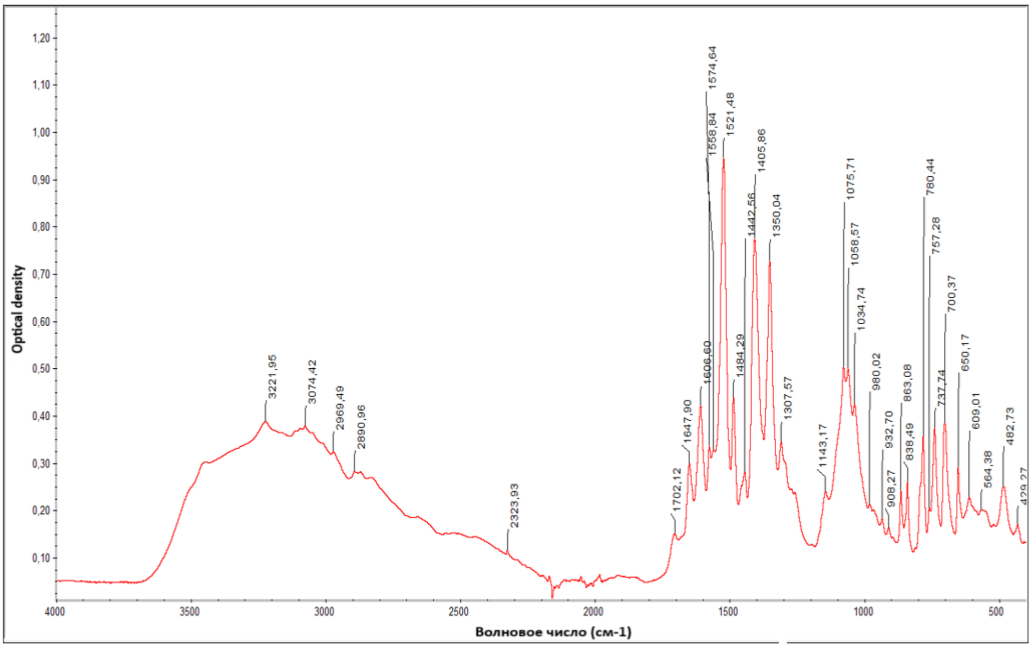

Figure 1.IR Spectrum of the Coordination Compound $[Zn(L)_2](NO_3)_2 \cdot 2H_2O$

The IR spectra of ketorolac, zinc(II) nitrate hexahydrate, and the coordination complex synthesized from these two components were analyzed. In the IR spectrum of ketorolac, distinct absorption bands were observed at 1720 and 1705 cm^{-1}, corresponding to the stretching vibrations of the C=O bond which are characteristic of the carboxylic acid group present in the ketorolac molecule. Additionally, absorption bands in the range of 2729–2749 cm^{-1} were identified, attributed to the O–H stretching vibrations of the carboxyl group. The IR spectrum of zinc(II) nitrate hexahydrate displayed characteristic vibrations associated with water molecules and nitrate ions. The O–H stretching vibrations of coordinated water appeared at 3369 and 3560 cm^{-1}, while nitrate-related bands were observed at 1320 and 1400 cm^{-1}. Furthermore, low-frequency bands in the range of 457–759 cm^{-1} were assigned to Zn–O vibrations. In the IR spectrum of the synthesized coordination complex based on ketorolac and zinc(II) nitrate, notable shifts in the C=O stretching frequencies were observed—from 1732 to 1739 cm^{-1} and from 1693 to 1683 cm^{-1}—indicating the coordination of the carbonyl oxygen with the Zn(II) ion. The disappearance of the broad O–H stretching bands further supports the deprotonation of the carboxylic group and its subsequent involvement in complex formation with the metal ion. Moreover, new absorption bands appeared in the range of 418–592 cm^{-1}, confirming the formation of Zn–O bonds. The IR spectrum of the complex also exhibited peaks at 1238 cm^{-1} (a shift from 1230 to 1238 cm^{-1}) and in the 623–671 cm^{-1} region, consistent with the presence of NO_3^- ions. These nitrate-related bands are not significantly shifted (e.g., 1230 → 1238 cm^{-1} represents a minor 12 cm^{-1} shift), and they are neither strongly split nor symmetrically arranged, indicating that the nitrate anions are not coordinated directly to the metal center but exist as free counter-ions in the outer coordination sphere [6].

Based on the IR spectral analysis presented above, the formation of a coordination complex between ketorolac and zinc(II) nitrate hexahydrate was confirmed. The ketorolac molecule coordinates to the Zn(II) ion through its carboxyl group. The key evidence supporting this includes the shift in the C=O stretching vibrations, the disappearance of O–H stretching bands, and the emergence of new bands characteristic of Zn–O bonds. These findings demonstrate that ketorolac, similar to other pharmaceutical agents such as ibuprofen, is capable of forming stable complexes with metal ions. Such coordination compounds have potential applications in pharmaceutical and biological systems.

Conclusion: The analysis also revealed that the nitrate ions are not directly coordinated to the metal center but remain as free anions in the outer coordination sphere. These findings demonstrate the structural stability of the complex. This work contributes to the methodology of synthesizing zinc-based coordination compounds and provides a theoretical foundation for their potential application in pharmaceutical and bioorganic chemistry.

References

1. M.E. Karimova., Sh.B. Hasanov., O.I. Khudoyberganov. Synthesis of a molecular complex compound of ketorolac with monoethanolamine // Development of science. December 2024/6. PP-9-17.
2. Coordination chemistry: textbook / V. V. Skopenko [et al.]. – M.: Akademkniga, 2007. – 488 p.
3. K.S.Rizayev, R.Kh.Sultanova, Z.T.Fayziyeva, N.V.Shilsova, F.A. Saydaliyeva. Fundamentals of clinical pharmacy and pharmacokinetics [Text]: textbook/-Tashkent: Ibn Sina Publishing House of the Tashkent Pharmaceutical Institute, 2023. -252 p.
4. V.G. Yusupov., M.T. Toshev., N.A. Parpiyev. Chemistry of coordination compounds, Tashkent. "University Publishing House", 1996.-298p.
5. K. Jagadesh Babu , Dasari Ayodhya, Shivaraj. Comprehensive investigation of Co(II), Ni(II) and Cu(II) complexes derived from a novel Schiff base: Synthesis, characterization, DNA interactions, ADME profiling, molecular docking, and in-vitro biological evaluation // Results in Chemistry Volume 6, December 2023, 101110. https://doi.org/10.1016/j.rechem.2023.101110

6. Nakamoto K. IR spectra of inorganic and coordination compounds // M.: Mir, 1996. - 204 p.