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Schiff Bases: Versatile Ligands with the Biological and Industrial Applications

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Description

Azomethines, commonly known as Schiff bases, are versatile chemical compounds with significant biological and industrial applications. They exhibit a wide range of activities, including antimicrobial, antioxidant and anticancer properties. Schiff bases are also utilized in the synthesis of coordination compounds, where they act as ligands for metal ions. Their azomethine linkage, characterized by a nitrogen-carbon double bond, contributes to their reactivity and biological effectiveness, particularly in inhibiting tumor cell growth. The hydrolysis of Schiff bases can facilitate their activity as antimetabolites, making them important in cancer treatment. Schiff bases also play a vital role in the development of various pharmaceutical agents, including antibiotics and antioxidants, by forming complexes with transition metals that exhibit enhanced biological functions. Heterocyclic compounds, especially pyrazoles, are central to organic chemistry due to their significant biological roles. Pyrazole, a five-membered ring compound containing two nitrogen atoms, is a key component in medicinal chemistry. Derivatives of pyrazole, such as 4-aminophenazone, have been synthesized and studied for their reactivity and biological properties. The heteroatom effect, resulting from the electron redistribution caused by the presence of heteroatoms, contributes to the compound's aromatic character, which in turn influences its reactivity, chelation properties and biological activity. Schiff bases derived from 4-aminophenazone are notable for their pharmacological, therapeutic and anti-inflammatory properties. These derivatives serve as a foundation for designing novel drugs, particularly in the realms of pain management and cancer treatment.

Pharmacological significance of 4-aminophenazone derivatives

4-Aminophenazone derivatives are recognized for their diverse pharmacological activities, including analgesic, anti-inflammatory, antipyretic and antibacterial effects. These derivatives also demonstrate significant DNA-binding properties, which contribute to their potential anticancer activities. Transition metal complexes formed with Schiff base ligands, such as those containing Cu(II), Ni(II), Co(II), Zn(II) and VO(IV), have shown promising antibacterial activities, particularly against *E. coli* and *S. aureus*. Moreover, metal complexes with reduced ion polarity demonstrate enhanced antibacterial and antifungal activities. Studies also suggest that the Cu(II) complex has superior anti-cancer properties compared to other metal complexes, underscoring its potential as a therapeutic agent.

Supramolecular assembly

Inspired by the potential applications of 4-aminophenazone derivatives, current research focuses on exploring their supramolecular assembly and molecular interactions using advanced techniques such as Single-Crystal X-Ray Diffraction (SC-XRD), High-Resolution Spectroscopy (HSA) and Density Functional Theory (DFT) studies. Molecular docking studies are vital in evaluating the binding behavior of synthesized compounds with target proteins, which may provide insights into their mechanisms of action. These *in silico* investigations are valuable tools in contemporary drug discovery, as they help identify potential candidates for therapeutic and antitumor drug development. The use of computational methods to explore the interaction between Schiff base derivatives and biological macromolecules further enhances the understanding of their pharmacological properties and potential clinical applications.

Conclusion

Schiff bases, particularly derivatives of 4-aminophenazone, hold considerable assurance for the development of novel therapeutic agents. Their wide-ranging biological activities, including antimicrobial, anticancer and DNA-binding properties, make them invaluable in drug discovery efforts. The synthesis of metal complexes and the exploration of their supramolecular properties *via* SC-XRD, HSA, DFT studies and molecular docking provide valuable insights into their structure-activity relationships. These findings open new method for designing effective treatments for various diseases, including cancer and for further expanding the potential applications of Schiff bases in pharmaceutical and medicinal chemistry.