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Recent Progress in Zn(II)-Coordinated Molecular Probes for Pyrophosphate Detection

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Abstract: Pyrophosphate (PPi) is an important biomarker involved in numerous intracellular processes and is associated with several human diseases. It is critically involved in a variety of biological reactions, particularly in the formation of nucleic acids (DNA and RNA). Thus, the advancement of selective receptors for PPi ions that allow real-time monitoring of intracellular PPi levels in living systems is of great importance. PPi is found in synovial fluid, blood plasma, and urine at concentrations that effectively inhibit abnormal calcification by acting as a natural suppressor of hydroxyapatite formation. It is also involved in essential biological functions such as cell growth, chromosomal elongation, energy storage and transduction, and iron delivery. However, elevated levels of PPi can lead to complexation with calcium ions, resulting in the formation of microscopic calcium pyrophosphate crystals that deposit in joints and cause calcium pyrophosphate deposition (CPPD) disease. Due to its vital biological functions and pathological relevance, the development of novel chemosensors capable of selectively detecting PPi in aqueous environments under physiological conditions continues to be a compelling and dynamic research focus. Over time, numerous chemosensors have been reported for PPi detection, with fluorescent systems receiving special interest due to their exceptional sensitivity, accurate detection, real-time measuring potential, and relevance in bioimaging applications. Among luminescent probes, Zn(II)-based metal complexes stand out for their excellent biocompatibility and favorable water solubility. This review systematically compiles and discusses Zn(II) metal complex-based chemosensors designed for the selective recognition of pyrophosphate ions.

Keywords: Pyrophosphate, molecular recognition, sensing, PPi, bio-imaging, Zn(II) complex

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