Enhancing Biomedical Applications of Zirconium-Based Nanocages: Overcoming Solubility and Uptake Challenges

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Abstract:

Nanoscale molecular materials are garnering increasing attention due to their multifunctionality and ease of modification. These materials tackle the shortcomings of conventional nanomaterials, such as ambiguous structure, composition, and particularly, lack of reproducibility. The lack of reproducibility results in substantial performance discrepancies among nanomaterials from different production batches. While such variability may be acceptable in chemical engineering, it greatly limits the use of conventional nanomaterials in biomedicine because it complicates quality control and in vivo monitoring. Therefore, nanoscale molecular materials are a major focus for the future advancement of nanomaterials, offering wide-ranging application possibilities. Zirconium-based nanocages, featuring stable Zr-O clusters, are notable for their outstanding stability and adaptable functionality via different ligands, making them a promising molecular nanomaterial. Nonetheless, their low water solubility and restricted ability to be taken up by cells impede their progress in biological uses. In this research, we describe nanocages that boost water solubility significantly by adding positively charged ruthenium complexes, which also offer excellent photoluminescence characteristics with large Stokes shifts. Moreover, modifying with butyl adjusts the hydrophilic and lipophilic characteristics of the nanocages, leading to a 100-fold enhancement in cellular uptake efficiency.

Keywords:

Cellular Internalization, Hydrophilicity-lipophilicity balance, Metal-organic cages.