

Next-generation therapeutics: unlocking the power of lanthanide compounds with phosphorus-containing ligands

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The continuing challenge of drug resistance and the limited efficacy of anticancer conventional therapies underlines the urgent need to develop new medicinal strategies. Metal-based compounds have appeared as promising candidates in medicine, especially in oncology, including lanthanides offering exceptional physicochemical properties such as luminescence, paramagnetism, and radiotherapeutic potential. Despite their growing obvious role in diagnostics and imaging, the biological applications of lanthanide compounds remain underexplored, although a few are used in the clinic including radiopharmaceutical, radioligand therapy, radioimmunotherapy and radioembolization device exist for specific purposes. There is a particularly low number of lanthanide complexes containing phosphorus-based ligands. That is why, this work highlights the potential of lanthanide inorganic compounds with phosphorus-based ligands, especially phosphine and phosphine oxide ligands coordinated to the metal ion as multifunctional anticancer agents. These compounds exhibit strong versatility, and ability to stabilize lower oxidation states of metal ions, enabling their use in numerous therapeutic modalities, such as chemotherapy, radiotherapy, photodynamic therapy (PDT), and theranostics. The integration of lanthanide ions with organophosphine ligands offers a promising platform for targeted drug delivery, multimodal treatment, and personalized medicine. This manuscript provides an overview of current clinical and preclinical reports and as such, highlighting the untouched potential of the combined lanthanide–phosphine class of inorganic compounds that could be developed as a next-generation therapy, especially towards cancer diseases.

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