Design principles of phosphors for visible-to-UVC upconversion

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Ultraviolet C (UVC) radiation plays a crucial role in medicine and industry, with applications ranging from sterilization to semiconductor manufacturing, and UV-curing technologies. Currently, UVC radiation is generated using mercury lamps for disinfection purposes and excimer lasers for technological processes. But these systems are bulky, which drives the search for compact and efficient UVC sources.

Light-emitting diodes (LEDs) are promising candidates, yet their efficiency and operational lifetime decrease significantly at wavelengths shorter than 260 nm. An alternative approach is to combine highly efficient blue LEDs with phosphor materials capable of converting visible light into UVC radiation [1]. Such a strategy could be particularly attractive if the efficiency of upconversion processes can be substantially improved.

For last four years, we have been investigating phosphor materials capable of converting visible light into UVC. Hence, in this lecture, I will present the design principles that guided the identification of efficient phosphors for blue-to-UVC conversion. These include the selection of suitable activator ions, tuning of host lattice effects on the relative positions of 5d and 4f electronic states, and control of phonon energies to minimize nonradiative losses [2]. I will also discuss the most promising host materials for solar excitation and briefly outline the historical development of this research field.

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[2] Zdeb-Stańczykowska P., Rebrova N., Dereń P.J. Inorg. Chem. (2025) 64(49) 23999–24011.

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