

Blue-to-NIR energy transfer for bifunctional application in indoor agriculture and high-temperature luminescent thermometry

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Streszczenie

We report on a novel series of multifunctional luminescent materials based on a $\text{Mg}_2\text{Al}_4\text{Si}_5\text{O}_{18}$ aluminosilicate host doped with Ce^{3+} and co-doped with Cr^{3+} ions, synthesized via a sol-gel route. The synthesized phosphors exhibit broadband blue emission originating from the parity-allowed $5d \rightarrow 4f$ transitions of Ce^{3+} , efficiently converted into narrow red/NIR emission from spin-forbidden ${}^2\text{E} \rightarrow {}^4\text{A}_2$ transitions of Cr^{3+} via an efficient $\text{Ce}^{3+} \rightarrow \text{Cr}^{3+}$ energy transfer mechanism. This emission profile, highly matched to the absorption bands of key plant photoreceptors (chlorophylls, carotenoids, and phytochromes), makes the material highly suitable for agricultural LED lighting applications. The optimized co-doping strategy enables energy transfer efficiencies up to 54% and photoluminescence quantum yields reaching 41%, establishing these phosphors as promising candidates for UV-excited LEDs for plant growth. Beyond lighting, the material demonstrates excellent performance as an optical luminescent thermometer. Temperature-dependent studies reveal high relative sensitivities of $0.51\% \cdot \text{K}^{-1}$ (525K) and $0.97\% \cdot \text{K}^{-1}$ (497K) based on emission intensity ratios and lifetime measurements, respectively. The thermometric function enables in situ, non-contact temperature sensing of illuminated plant tissues, addressing critical needs in precision agriculture. The simultaneous presence of Ce^{3+} -based blue emission and Cr^{3+} -centered red/NIR luminescence, facilitated by efficient energy transfer between the dopants, highlights the potential of $\text{Mg}_2\text{Al}_4\text{Si}_5\text{O}_{18} : \text{Ce}^{3+}, \text{Cr}^{3+}$ for dual-use in plant-targeted LED lighting and optical temperature sensing.

Słowa kluczowe

Aluminosilicates, Ce^{3+} ions, Cr^{3+} ions, Energy transfer, Luminescence thermometry, Plant growth, Indoor agriculture

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