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Dye-sensitized blue-to-UVB upconversion nanocrystals for phototherapy

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Phototherapy using narrowband UVB artificial light sources is widely used to effectively treat skin diseases like psoriasis and erythema. However, severe side effects can occur by the UVB exposure of healthy skin surrounding affected areas. Here, we propose a new method based on a blue–to–UVB upconversion material, NaYF4:Ho3+,Gd3+, as an alternative and safer treatment in which UVB radiation is applied locally. Following the absorption of two blue photons around 447 nm by Ho3+ and cross–relaxation between neighboring Ho3+ ions, a highly excited Ho3+ ion resonantly transfers its energy to a nearby Gd3+ ion, which emits narrow UVB emission at 311 nm. Absorption for the parity forbidden intra–4f10 Ho3+ transitions is weak. To enhance the UV upconversion emission intensity, dye molecules with strong blue absorption were designed to serve as antennas after binding withNaYF4:Ho3+,Gd3+ nanoparticles (NPs). By employing a direct binding procedure, we succeeded in obtaining various systems of PPA2 dyes bound to NaYF4:Ho3+,Gd3+ NPs. NPs with PPA2 dyes excited at ~430 nm show blue–to–UVB upconversion with a 10–100 time shigher upconversion emission intensity compared to the bare NPs. Dye–sensitizedupconversion involves strong absorption of blue light by the PPA2 dye ‘antenna’ followed by energy transfer to Ho3+, upconversion by energy transfer between excited Ho3+ neighbours and energy transfer from Ho3+ to Gd3+. Proofs for dye → Ho3+ ET were provided systematically. Blue–to–UVB upconversion is a novel field of research. The encouraging results obtained for the Ho3+–Gd3+ couple will be further investigated and optimized to realize safer therapy for skin diseases relying on blue LEDs and suitable for home treatment.

SHORT BIO:

Dechao Yu received his PhD degree of Materials Science from South China University of Technology under the supervision of Prof. Qinyuan Zhang in 2014. Then he joined Prof. Riman’s group at the Rutgers University for a 3 years’ post–doctoral project on the topic of efficient SWIR nanoparticles for bioimaging. Currently he is a postdoctoral researcher in the CMI group of Prof. Meijerink, and studies the blue–to–UVB upconversion as well as its dye–sensitization for phototherapy.

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