Electronic Supplementary Material (ESI) for Dalton Transactions.

Electronic supplementary information (ESI)

Gd^{3+}-activated narrowband ultraviolet-B persistent luminescence through persistent energy transfer

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This ESI file contains: XRD patterns of NB-UVB persistent phosphors $Sr_3Gd_2Si_6O_{18}:Pr^{3+}$, $Sr_3Gd_2Si_6O_{18}:Pb^{2+}$, $Y_2GdAl_2Ga_3O_{12}:Pr^{3+}$ and $Y_2GdAl_2Ga_3O_{12}:Bi^{3+}$, persistent luminescence properties of NB-UVB persistent phosphors $Ca_{1.8}Gd_{0.2}Al_2SiO_7:Pr^{3+}$, $Lu_{1.8}Gd_{0.2}SiO_5:Pr^{3+}$, $Ca_{2.8}Gd_{0.2}Al_2Si_3O_{12}:Pr^{3+}$, $LiY_{0.8}Gd_{0.2}SiO_4:Pr^{3+}$, $Sr_3Y_{2-x}Gd_xSi_6O_{18}:Pb^{2+}$, $Lu_2GdAl_2Ga_3O_{12}:Pr^{3+}$ and $Lu_2GdAl_2Ga_3O_{12}:Bi^{3+}$, persistent luminescence properties of UVB persistent phosphors $Lu_3Al_2Ga_3O_{12}:Pr^{3+}$ and $Lu_3Al_2Ga_3O_{12}:Bi^{3+}$, and conceptual self-sustained NB-UVB Band-Aid phototherapy.

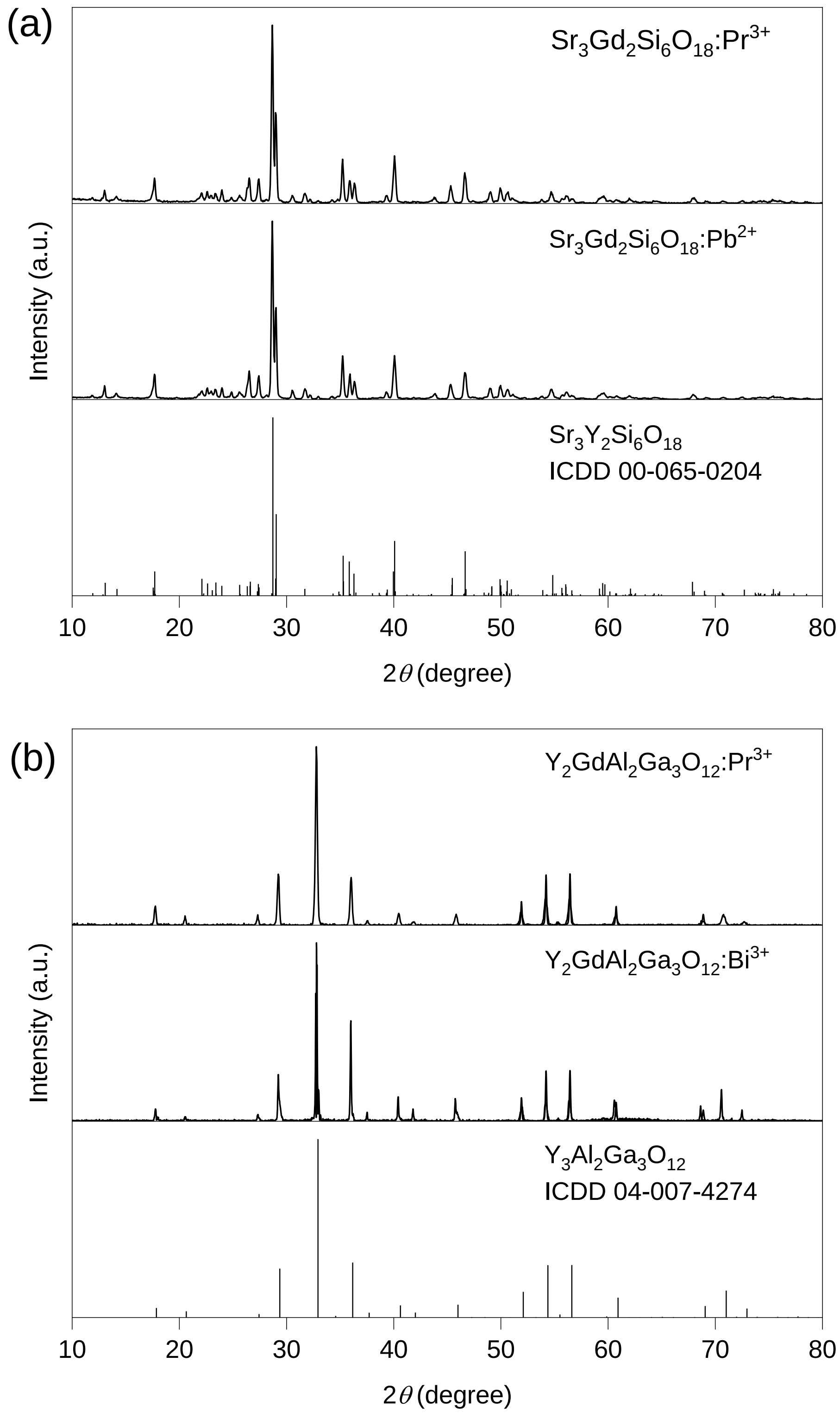

Fig. S1 X-ray diffraction (XRD) patterns. (a) XRD patterns of $Sr_3Gd_2Si_6O_{18}:Pr^{3+}$ and $Sr_3Gd_2Si_6O_{18}:Pb^{2+}$ persistent phosphors. These two $Sr_3Gd_2Si_6O_{18}$ phosphors share the same XRD pattern with the cyclosilicate $Sr_3Y_2Si_6O_{18}$ (ICDD 00-065-0204). In the cyclosilicate $Sr_3Y_2Si_6O_{18}$, Sr/Y atom layers and Si_3O_9 ring layers are stacking along the [101] direction.[1] (b) XRD patterns of $Y_2GdAl_2Ga_3O_{12}:Pr^{3+}$ and $Y_2GdAl_2Ga_3O_{12}:Bi^{3+}$ persistent phosphors. These two $Y_2GdAl_2Ga_3O_{12}$ phosphors have the same XRD pattern as the garnet $Y_3Al_2Ga_3O_{12}$ (ICDD 04-007-4274). The garnet $Y_3Al_2Ga_3O_{12}$ consists of a co-edge $[AlO_6]/[GaO_6]$ octahedron, an $[AlO_4]/[GaO_4]$ tetrahedron and a distorted $[YO_8]$ dodecahedron.[2]

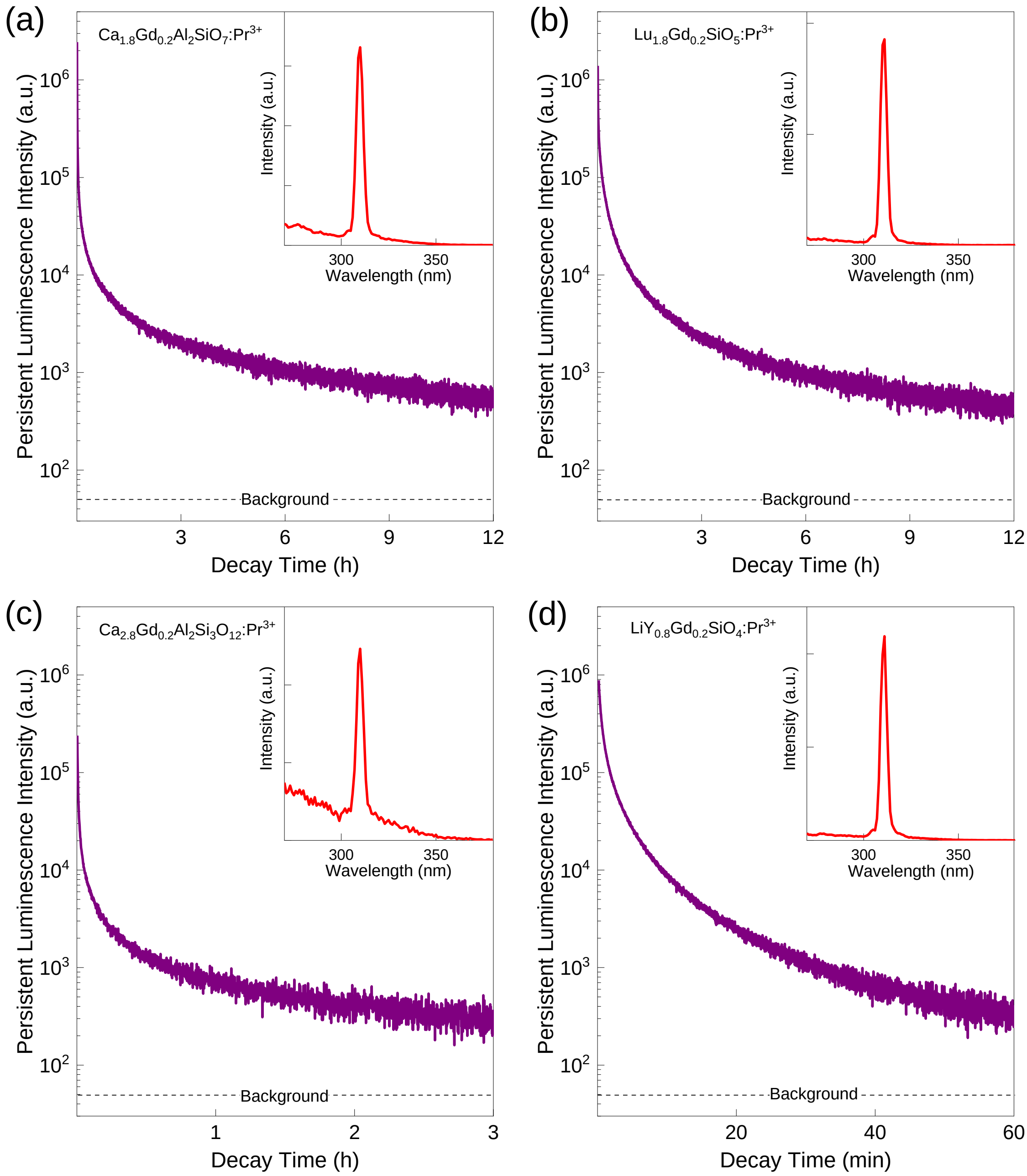

Fig. S2 Persistent luminescence decay curves and persistent luminescence emission spectra of Gd^{3+}-activated, Pr^{3+}-sensitized NB-UVB persistent phosphors developed from Pr^{3+}-activated UVC persistent phosphors. (a) $Ca_{1.8}Gd_{0.2}Al_2SiO_7:Pr^{3+}$ ($Ca_2Al_2SiO_7:Pr^{3+}$). (b) $Lu_{1.8}Gd_{0.2}SiO_5:Pr^{3+}$ ($Lu_2SiO_5:Pr^{3+}$). (c) $Ca_{2.8}Gd_{0.2}Al_2Si_3O_{12}:Pr^{3+}$ ($Ca_3Al_2Si_3O_{12}:Pr^{3+}$). (d) $LiY_{0.8}Gd_{0.2}SiO_4:Pr^{3+}$ ($LiYSiO_4:Pr^{3+}$). The phosphor in the bracket after each Gd^{3+} NB-UVB phosphor is the corresponding Pr^{3+}-activated UVC benchmark material. The phosphors were pre-irradiated by a 254 nm lamp for 5 min. The decay curves were recorded by monitoring the Gd^{3+} 311 nm emission. The inset in each figure shows the persistent luminescence emission spectrum recorded at 10 min decay.

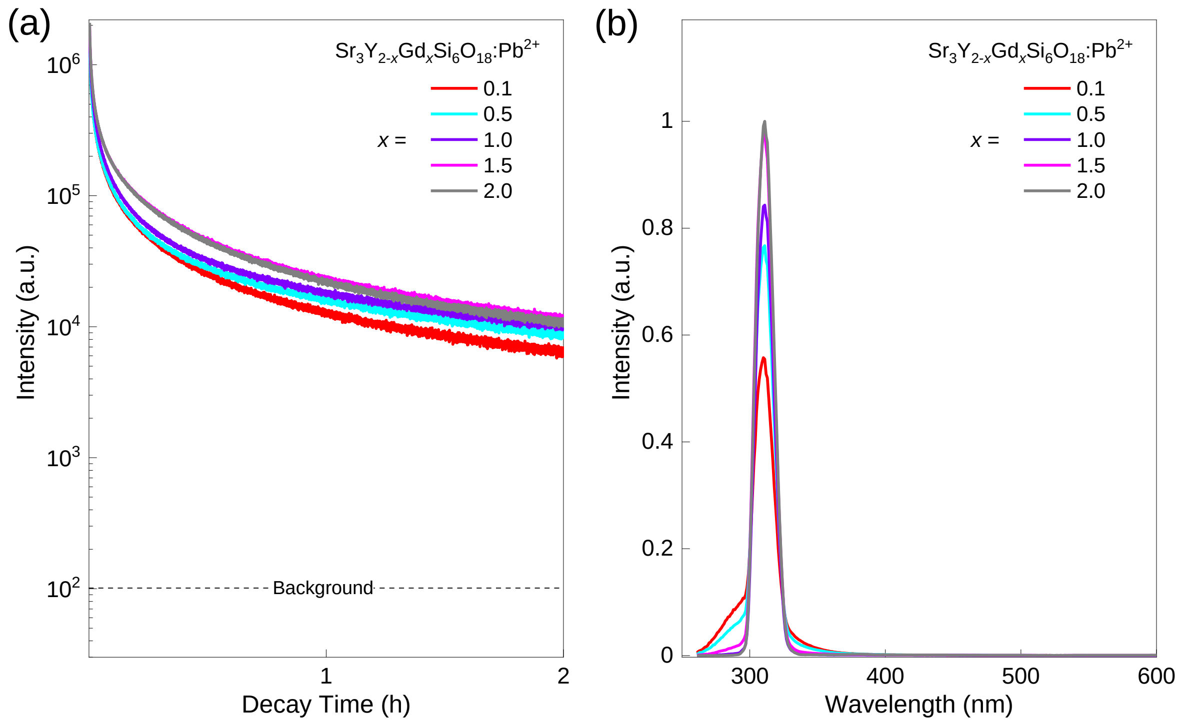

Fig. S3 Persistent luminescence properties of $Sr_3Y_{2-x}Gd_xSi_6O_{18}:Pb^{2+}$ (x = 0.1, 0.5, 1.0, 1.5, 2.0) NB-UVB persistent phosphors developed from a $Sr_3Y_2Si_6O_{18}:Pb^{2+}$ UVB persistent phosphor. (a) Persistent luminescence decay curves. The monitoring wavelength is 311 nm. (b) Persistent luminescence emission spectra acquired at 10 min decay. The phosphors were pre-irradiated by a 254 nm lamp for 5 min.

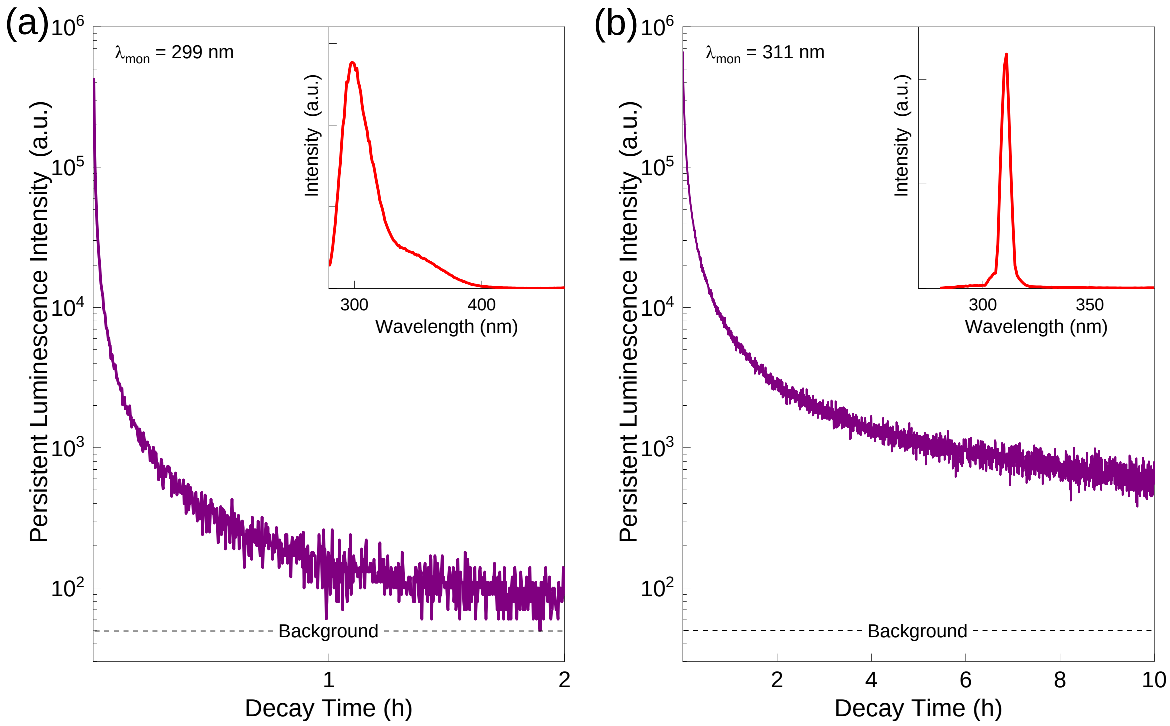

Fig. S4 $Lu_2GdAl_2Ga_3O_{12}:Pr^{3+}$ NB-UVB persistent phosphor developed from $Lu_3Al_2Ga_3O_{12}:Pr^{3+}$ UVB persistent phosphor. (a) Persistent luminescence decay curve of $Lu_3Al_2Ga_3O_{12}:Pr^{3+}$ UVB persistent phosphor monitored at 299 nm emission. (b) Persistent luminescence decay curve of $Lu_2GdAl_2Ga_3O_{12}:Pr^{3+}$ NB-UVB persistent phosphor monitored at 311 nm emission. The inset in each figure shows the persistent luminescence emission spectrum recorded at 10 min decay. The phosphors were pre-irradiated by a 254 nm lamp for 5 min.

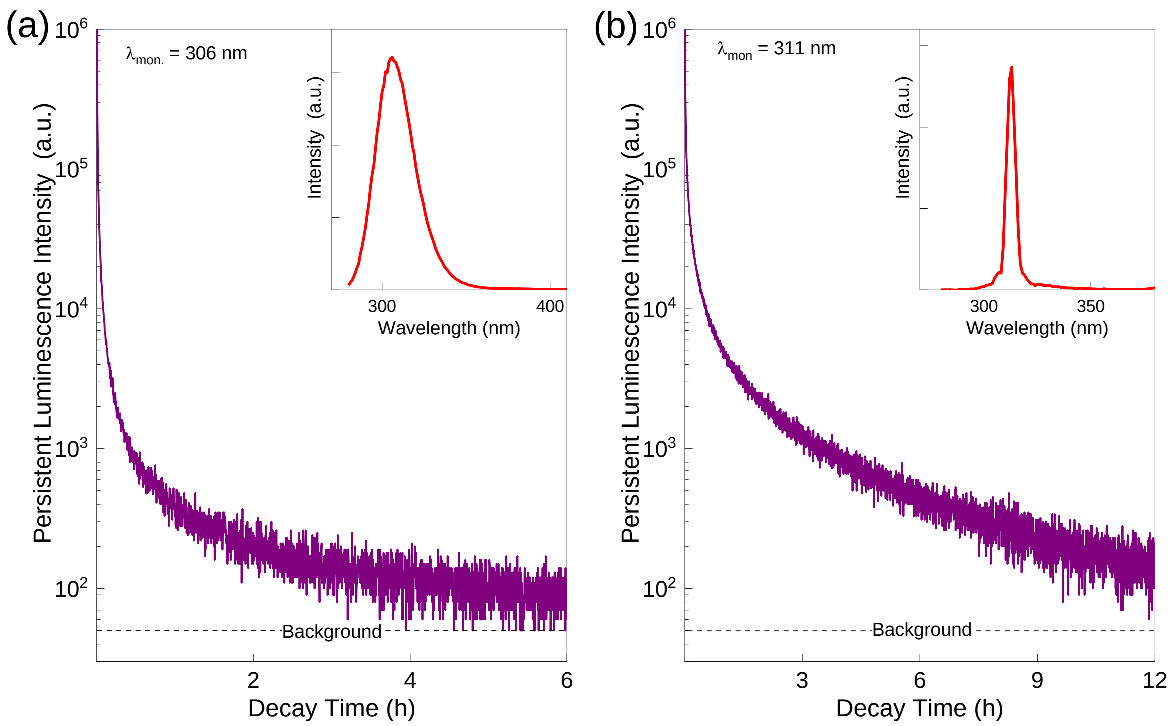

Fig. S5 $Lu_2GdAl_2Ga_3O_{12}:Bi^{3+}$ NB-UVB persistent phosphor developed from $Lu_3Al_2Ga_3O_{12}:Bi^{3+}$ UVB persistent phosphor. (a) Persistent luminescence decay curve of $Lu_3Al_2Ga_3O_{12}:Bi^{3+}$ UVB persistent phosphor monitored at 306 nm emission. (b) Persistent luminescence decay curve of $Lu_2GdAl_2Ga_3O_{12}:Bi^{3+}$ NB-UVB persistent phosphor monitored at 311 nm emission. The inset in each figure shows the persistent luminescence emission spectrum recorded at 10 min decay. The phosphors were pre-irradiated by a 254 nm lamp for 5 min.

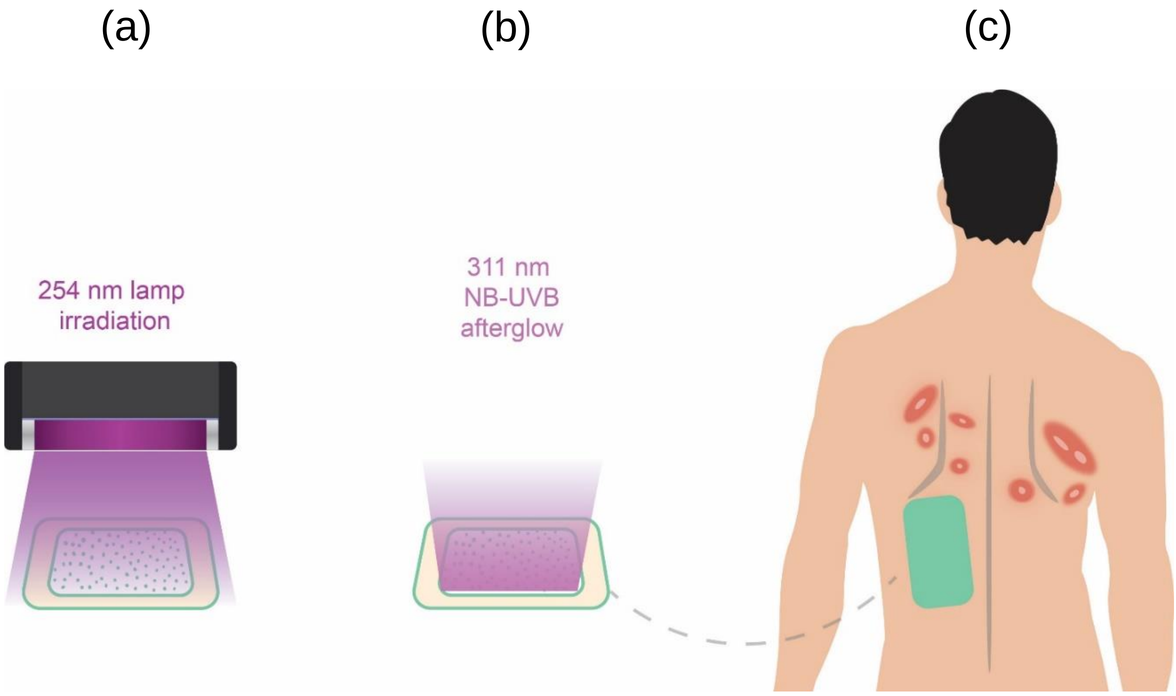

Fig. S6. Concept of self-sustained NB-UVB Band-Aid phototherapy for the treatment of small-area skin disorders. (a) A Band-Aid bearing Gd^{3+}-activated NB-UVB persistent luminescent micro-powders (e.g., $Sr_3Gd_2Si_6O_{18}:Pr^{3+}$) is being charged by a portable, battery-powered 254 nm mercury lamp. (b) After the excitation is ceased, the Band-Aid emits Gd^{3+} 311 nm afterglow. (c) The glowing Band-Aid is stuck onto the affected skin region for treatment. The Band-Aid therapy has the potential advantages of being portable, less expensive, chargeable by the standard 254 nm mercury lamps, rechargeable with indefinite lifetimes, and tailorable to precisely fit the size and shape of the affected skin region. Moreover, the Band-Aid therapy does not affect the patients' normal activities while they are being treated.

References

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2. C. B. Zheng, P. X. Xiong, M. Y. Peng and H. L. Liu. *J. Mater. Chem. C*, 2020, **8**, 13668.