Supporting information

An intense NIR emission from Ca$_{14}$Al$_{10}$Zn$_6$O$_{35}$:Mn$^{4+}$,Yb$^{3+}$ via energy transfer for solar spectral convertor

Wei Lü$^{a,*}$, Mengmeng Jiao$^{a,b}$, Baiqi Shao$^{a,b}$, Lingfei Zhao$^{a,b}$, Yang Feng$^{a,b}$ and Hongpeng You$^{a,*}$

$^a$State key Laboratory of Rare Earth Resource Utilization, Changchun Institute of Applied Chemistry, Chinese Academy of Sciences, Changchun 130022, P. R. China.

$^b$University of the Chinese Academy of Sciences, Beijing 100049, P. R. China.
Experimental Section

Synthesis. The Ca$_{14-x}$Al$_{9.85}$Zn$_6$O$_{35}$ (CAZO) : $0.15$Mn$^{4+}$, $x$Yb$^{3+}$ (abbreviated as CAZO: Mn$^{4+}$, $x$Yb$^{3+}$; Mn$^{2+}$ substitutes for Al$^{3+}$, Yb$^{3+}$ substitutes for Ca$^{2+}$, where the $x$ is mole percent) phosphors were synthesized by a high-temperature solid-state reaction. The constituent oxides or carbonates CaCO$_3$ (A. R.), ZnO (A. R.), Al$_2$O$_3$ (A. R.), MnCO$_3$ (A. R.) and Yb$_2$O$_3$ (99.99%) were employed as the raw materials, which were mixed homogeneously by an agate mortar for 30 minutes, placed in a crucible with a lid, and then sintered in a tubular furnace at 1220°C for 4 h in air.

Characterization. The phase purity of all samples were identified by powder X-ray diffraction (XRD) analysis (Bruker AXS D8), with graphite monochromatized Cu Kα radiation ($\lambda = 0.15405$ nm) operating at 40 kV and 40 mA. The morphology and size of the as-prepared samples were inspected with a field emission scanning electron microscope equipped with an energy-dispersive spectrometer (EDS) (FE-SEM, S-4800, Hitachi, Japan). High-resolution transmission electron microscopic (HRTEM) images were recorded with a FEI Tecnai G2 S-Twin with a field-emission gun operating at 200 kV and a Gatan multipe multiple CCD camera. Room-temperature photoluminescence (PL) spectra were measured on a Hitachi F-7000 luminescence spectrophotometer equipped with a 150 W xenon lamp as the excitation source. Absolute photoluminescence quantum yields (QYs) were measured by the absolute PL quantum yield measurement system (C9920-02, Hamamatsu Photonics K. K., Japan). The luminescence decay curves were obtained from a Lecroy Wave Runner 6100 digital oscilloscope (1GHz) using a tunable laser (pulse width = 4 ns, gate = 50 ns) as the excitation source (Continuum Sunlite OPO).
Figure S1. Absolute quantum yields of the Ca$_{14}$Al$_{10}$Zn$_6$O$_{35}$:Mn$^{4+}$ excited with different wavelength.
Figure S2. PL spectra of CAZO:Mn$^{4+},x$Yb$^{3+}$ phosphors with different Yb$^{3+}$ concentrations under the excitation at 460 nm.