Electronic Supplementary Material (ESI) for Journal of Materials Chemistry C.

$KMnF_3$: Yb^{3+}, Er^{3+} @ $KMnF_3$: Yb^{3+} active-core-active-shell nanoparticles with enhanced red up-conversion fluorescence for polymer-based waveguide amplifiers operating at 650nm

Yongling Zhang,[1] Fei Wang,[1] Yanbo Lang, Jiao Yin, Meiling Zhang, Xiaohui Liu, Daming Zhang, Dan Zhao*, Guanshi Qin*, Weiping Qin*

[1]These authors contributed equally to this work.

Received (in XXX, XXX) Xth XXXXXXXXX 20XX, Accepted Xth XXXXXXXXX 20XX
DOI: 10.1039/b000000x

Supporting information

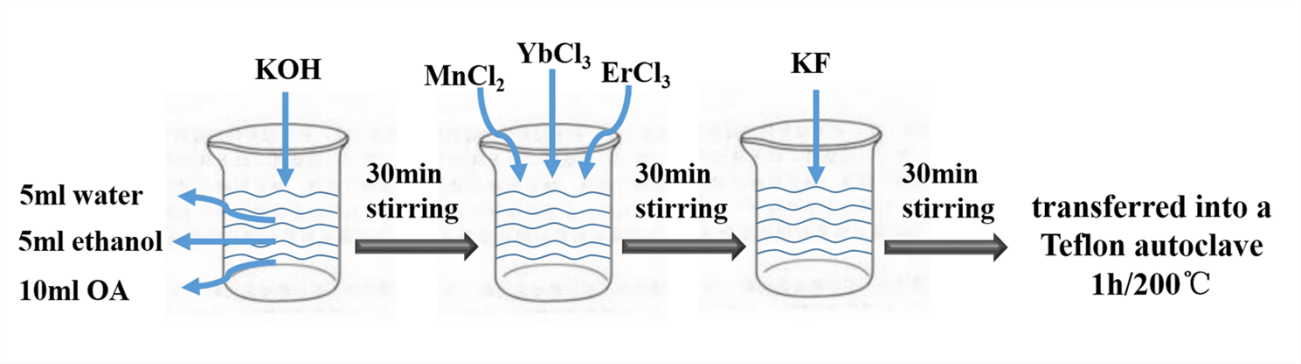

Fig. S1 Synthetic Procedure for the $KMnF_3$: Yb^{3+}, Er^{3+} Core Nanoparticle.

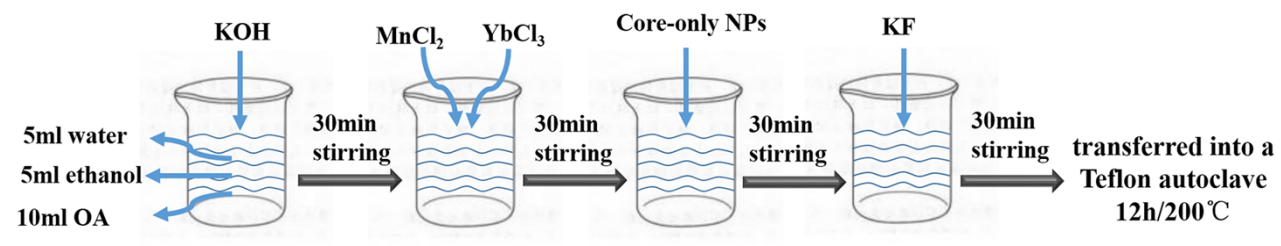

Fig. S2 Synthetic Procedure for the $KMnF_3$: Yb^{3+}, Er^{3+} @ $KMnF_3$: Yb^{3+} Core–Shell Nanoparticle.

5

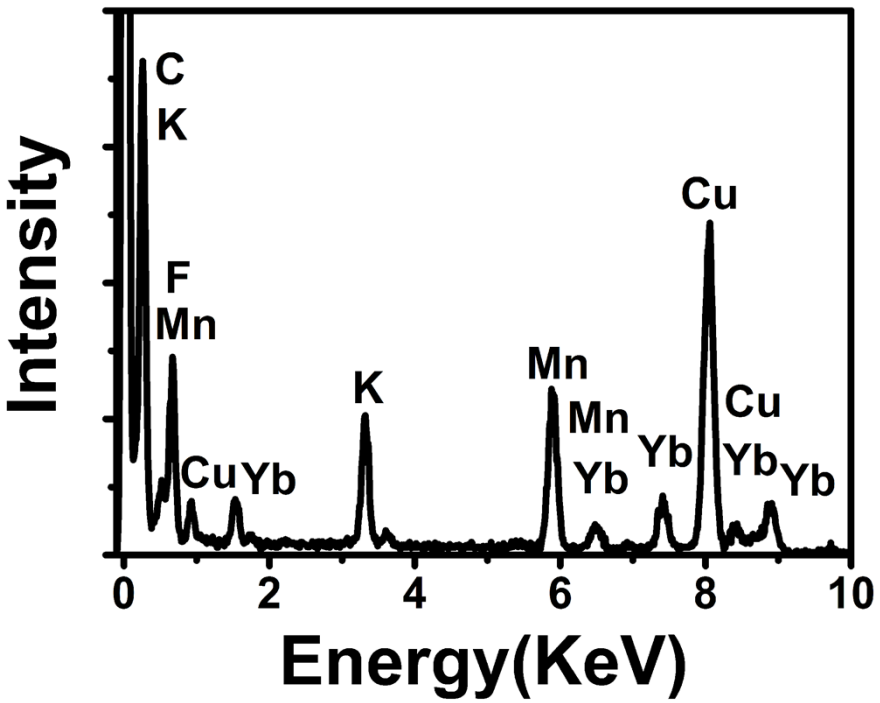

Fig. S3 The energy-dispersive X-ray spectrum of the $KMnF_3$: 18% Yb^{3+}, 1% Er^{3+}@ $KMnF_3$: 2% Yb^{3+} NPs.

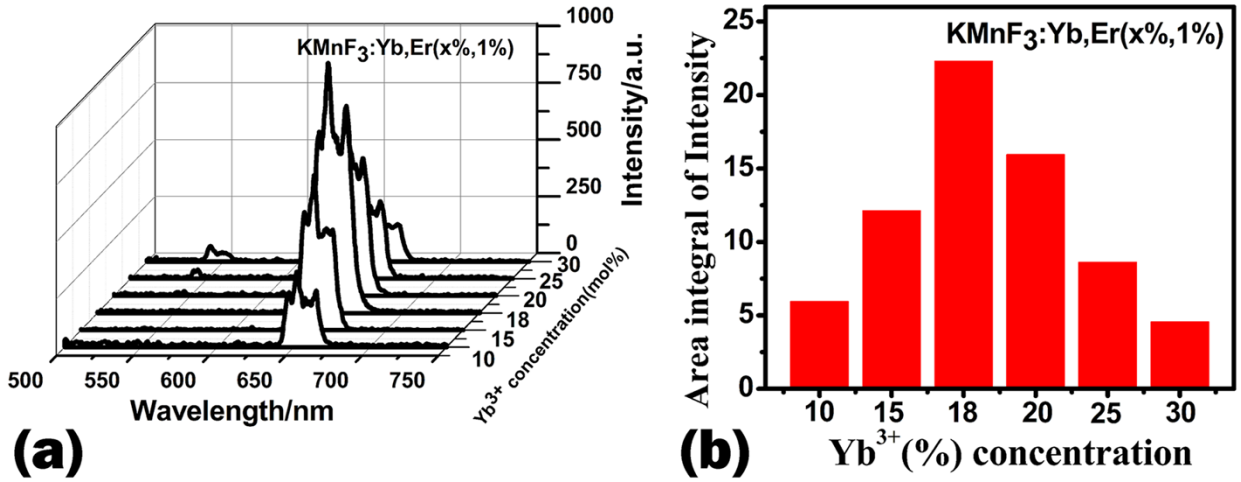

Fig. S4 (a) UC emission spectra of $KMnF_3$: x% Yb^{3+}, 1% Er^{3+} NPs. (b) Intensity enhancement of UC emission depending on the Yb^{3+} concentrations in the $KMnF_3$: x% Yb^{3+}, 1% Er^{3+} (x= 5, 10, 15, 18, 20, 25, 30) NPs.

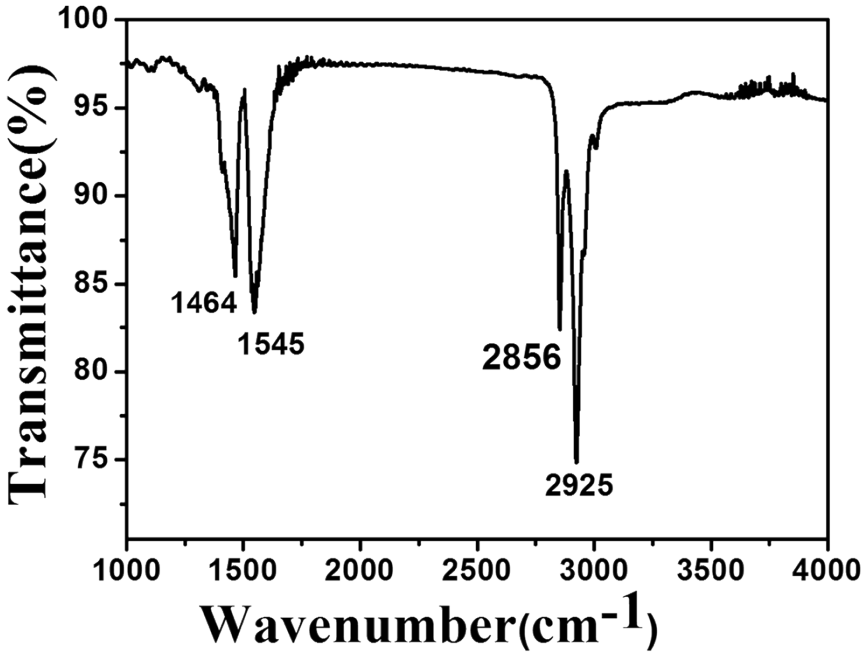

Fig. S5 The FTIR spectrum of the $KMnF_3$: 18% Yb^{3+}, 1% Er^{3+}@ $KMnF_3$: 2% Yb^{3+} (active-core-active-shell) NPs.

The active-core-active-shell NPs of $KMnF_3$: 18 mol% Yb^{3+}, 1 mol% Er^{3+}@$KMnF_3$: 2 mol%Yb^{3+} can be dispersed in nonpolar solution, because of there are hydrophobic OA ligands capping on the NPs. To clarify it, we measured the FTIR spectrum of $KMnF_3$: 18 mol% Yb^{3+}, 1 mol% Er^{3+}@$KMnF_3$: 2 mol%Yb^{3+} NPs, as shown in **Fig. S5**. The peaks at 2856 cm^{-1} and 2925 cm^{-1} are corresponding to the symmetric and asymmetric stretching of the methylene (CH_2) in the aliphatic chain of the oleic acid coating, respectively. The absorption peaks at 1545 cm^{-1} and 1464 cm^{-1} can be ascribed to the asymmetric and symmetric stretching vibrations of carboxylate anions bound to the surface of $KMnF_3$: 18 mol% Yb^{3+}, 1 mol% Er^{3+}@$KMnF_3$: 2 mol%Yb^{3+} NPs. Therefore, the NPs can be dispersed in nonpolar solvent (cyclohexane and toluene).

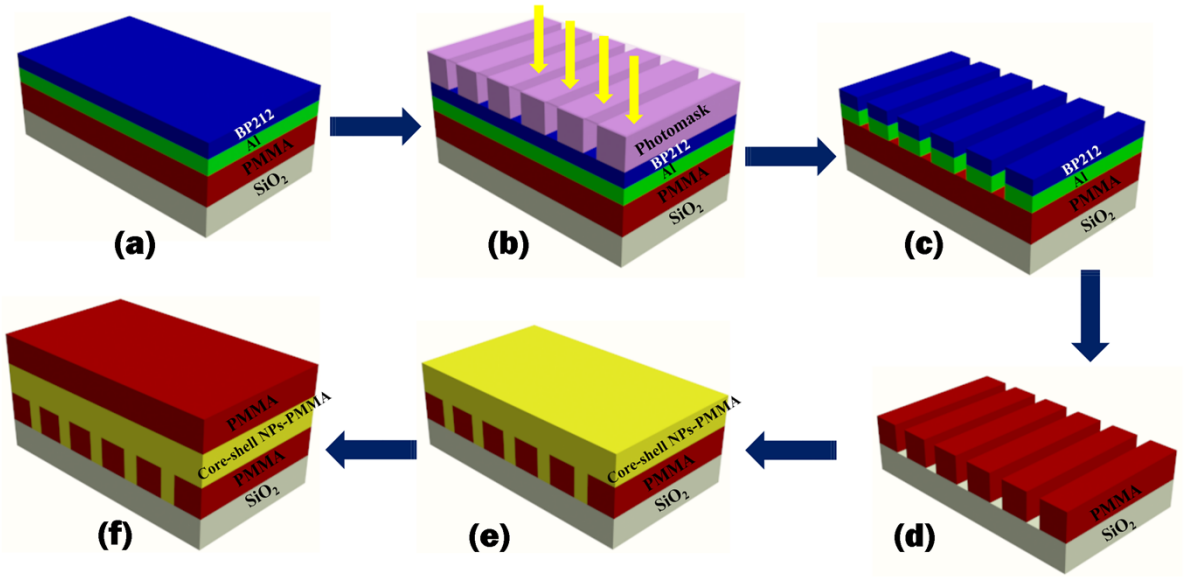

Fig. S6 Fabrication process for waveguide amplifier. (a) spin-coat and cure PMMA bottom cladding layer, evaporate Al mask, spin-coat and cure BP212 photoresist. (b) photolithography. (c) wet etching. (d) ICP etching, then remove the remaining Al mask and BP212. (e) spin-coat and $KMnF_3$: 18 mol% Yb^{3+}, 1 mol% Er^{3+} @ $KMnF_3$: 2 mol% Yb^{3+} NPs dispersed PMMA material. (f) spin-coat and cure PMMA cladding cladding layer.

The polymer-based waveguide amplifier was manufactured in three steps. Firstly, a PMMA film as bottom cladding layer was spin-coated onto a silicon dioxide layer based on silicon substrates, and cured at 120°C for 2 h. The waveguide pattern was fabricated by standard photolithography and ICP (inductively coupled plasma) etching technique using oxygen on the cladding layer. Secondly, the $KMnF_3$: 18 mol% Yb^{3+}, 1 mol% Er^{3+} @ $KMnF_3$: 2 mol% Yb^{3+} NPs dispersed PMMA was embedded into the grooves to constitute the core waveguides using spin-coating, and the device was baked at 100℃ for 2.5 h. Thirdly, a PMMA film was spin-coated as the upper cladding and baked at 120 °C for 2 h.