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Synthesis and Luminescent Properties of $YPO_4:Eu^{3+}$ Cornflakes Self-Assembled by Nanocrystals†

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A large-scale novel $YPO_4:Eu^{3+}$ cornflakes self-assembled by nanocrystals were synthesized by a facile hydrothermal method. X-Ray diffraction results show that the cornflakes are pure tetragonal structure. Transmission electron microscopy and selected area electron diffraction studies indicate that the $YPO_4:Eu^{3+}$ cornflakes are polycrystalline structure with a narrow size distribution. Photoluminescence spectra results demonstrate that the $YPO_4:Eu^{3+}$ cornflakes have two strong $^5D_0/^7F_1$ (590 nm) and $^5D_0/^7F_2$ (616 nm) transition peaks corresponding to orange-red and red colour, respectively.

Key Words: Rare earth, Nanomaterials, Hydrothermal, Self-assembly.

INTRODUCTION

In the past few years, all kinds of self-assembly hierarchical structure which the basic building blocks have specific morphology and novel properties have attracted considerable interest for their potential technology applications[1]. Though much progress has been made in the self-assembly of building blocks such as metals, semiconductors, copolymers, organic-inorganic hybrid materials and biomaterials[2,3], it is still a challenge for material scientists to achieve novel hierarchical self-assembly of some functional materials.

As an important group of inorganic materials with unique optical and electronic properties, nano and submicroscale rare earth orthophosphates ($RePO_4$) materials have been extensively studied[4]. Among different kinds of rare earth orthophosphates, YPO_4 crystallizes is physically robust and chemically stable for activator ions and has drawn much attention of the researchers. Partial substitution of Re^{3+} for Y^{3+} in YPO_4 is of particular interest in the production of luminescent materials and $YPO_4:Eu^{3+}$ is widely used in colour television, the cathode ray tube and the high-pressure mercury lamp *etc*.[5]. Compared to a lot of research efforts on constructing other lanthanide orthophosphates hierarchical structures, the fabrication about YPO_4 hierarchical structures is still limited. To the best of our knowledge, only Yang *et al.*[6] reported the synthesis of $YPO_4:Eu^{3+}$ olivary architectures composed of nanoflakes under three-step hydrothermal conditions. Hence, the fabrication of YPO_4 novel hierarchical structure remains a challenging issue faced by synthetic inorganic chemists.

Herein, we report the synthesis and luminescent properties of $YPO_4:Eu^{3+}$ cornflakes self-assembled by nanocrystals under facile hydrothermal conditions.

EXPERIMENTAL

All of the chemicals of analytic grade were purchased from Beijing Chemical Corporation and used as received without further purification. In a typical synthesis. Firstly, 3 mL 0.001 mol/mL NaF solution was added into 40 mL a mixed solution of $Y(NO_3)_3$ and $Eu(NO_3)_3$ under stirring for 0.5 h. Then 1 mL of 0.001 mol/mL $Na_5P_3O_{10}$ solution was slowly dropped to the above solution under vigorously stirring. After stirred for 0.5 h, the milky colloidal solution was obtained and poured into several Teflon-lined stainless steel autoclaves and then heated at 150 ºC for 5 h. After the autoclave was naturally cooled down to the room-temperature, the precipitates were collected by centrifugation and washed several times with distilled water and absolute ethanol and then dried at 60 ºC for 8 h.

RESULTS AND DISCUSSION

Phase identification of $YPO_4:Eu^{3+}$ cornflakes: Fig. 1 shows the XRD patterns of $YPO_4:Eu^{3+}$ cornflakes prepared by self-assembly route. The results indicate that all these samples have a single tetragonal xenotime structure with space group of $L4_1$/amd. Compared with the non-doped YPO_4 given in No. 84-0355 of JCPDS data files, the XRD pattern of Eu^{3+}-doped YPO_4 obtained in this work shows a slight shift of diffraction peaks for the large difference in the radius of Y^{3+} and Eu^{3+}.

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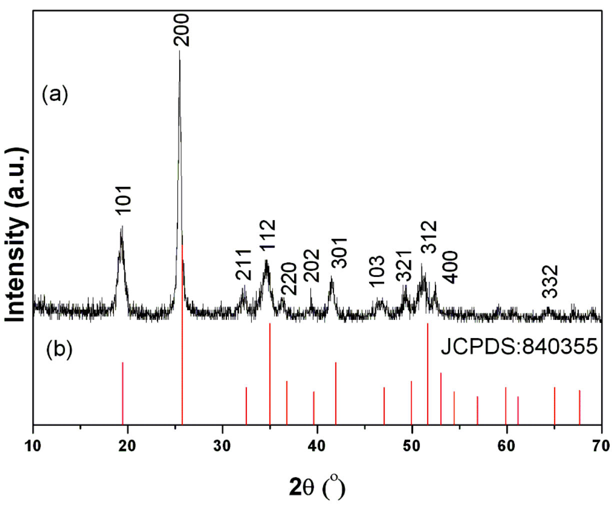

Fig. 1. XRD pattern for the $YPO_4:Eu^{3+}$ cornflakes

Morphology of $YPO_4:Eu^{3+}$ cornflakes: The morphologies of $YPO_4:Eu^{3+}$ and YPO_4 powders as prepared are shown in Fig. 2a-b, respectively. The morphologies of $YPO_4:Eu^{3+}$ as prepared is very like cornflakes shape consisting of nanoparticles. The size of the product distributes in the 100-200 nm range. From the insert in Fig. 2b, the strong diffraction rings of cornflakes are observed and can be well indexed to a tetragonal-phase structure, which is in good consonant with the results of XRD.

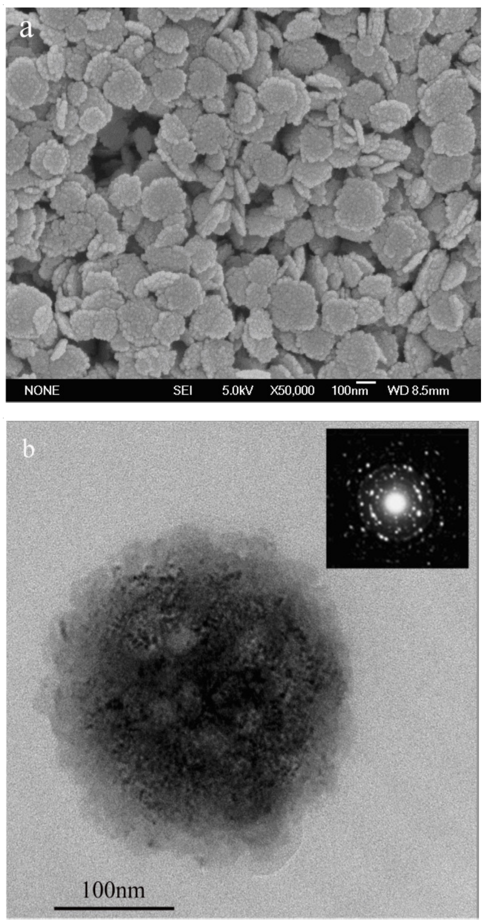

Fig. 2. SEM image (a), TEM image and SEAD pattern (b) of $YPO_4:Eu^{3+}$ cronflakes

Photoluminescent properties of $YPO_4:Eu^{3+}$ cornflakes: Fig. 3a shows the emission spectrum of the Eu^{3+}-doped YPO_4 cornflakes. It can be seen that the Eu^{3+}-doped cornflakes show two main emission bands with one centered at 590 nm (resulted from the electron transition from $^5D_0$ to $^7F_1$ levels of Eu^{3+}) and the other at 616 nm (produced by the electron transition from $^5D_0$ to $^7F_2$ levels of Eu^{3+}). Fig. 3b shows the excitation spectrum of the Eu^{3+}-doped YPO_4 cornflakes. The excitation spectrum consisting of a strong broad band with a maximum at 230 nm originates from the excitation of the oxygen-to-europium charge transfer band (CTB). The other weak lines in the longer wavelength region extending from 280-500 nm are assigned to the direct excitation of the Eu^{3+} ground state into higher levels of the 4*f*-manifold such as $^7F_0/^5L_6$ at 395 nm.

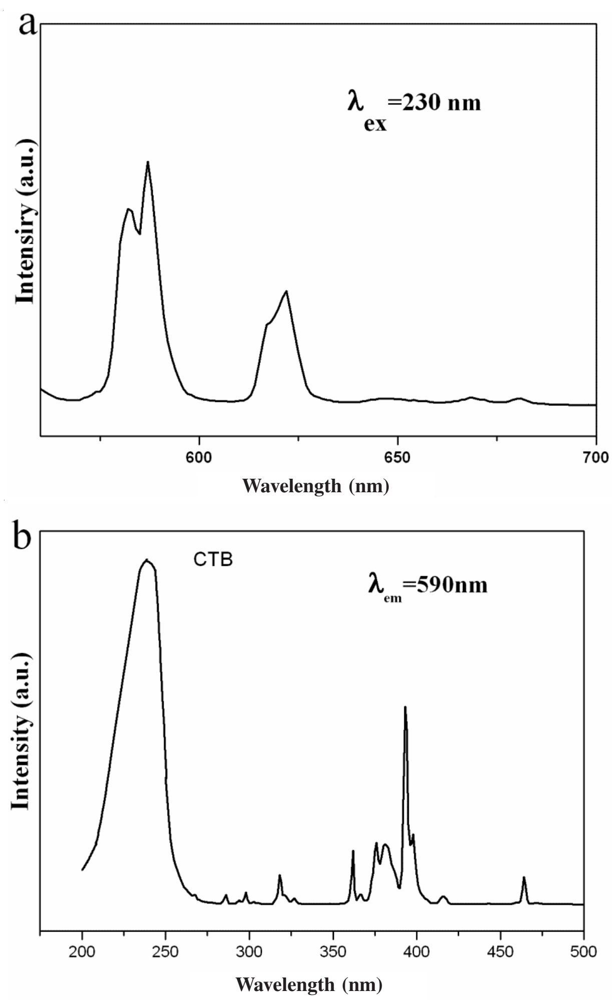

Fig. 3. Excitation spectra (a) and emission spectra (b) of the $YPO_4:Eu^{3+}$ cornflakes

Conclusion

A large-scale novel YPO_4: Eu^{3+} cornflakes self-assembled by nanocrystals have been synthesized successfully under a facile hydrothermal condition. The luminescent property indicates that the $YPO_4:Eu^{3+}$ architectures possess 2 lines for the $^5D_0/^7F_1$ transitions and 2 lines for the $^5D_0/^7F_2$ transitions, which are coincident with crystal field analysis and selection rules. The obtained architectures may have potential applications in the fields of optoelectronic devices.

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