Synthesis of $In(OH)_3$ and In_2O_3 Nanomaterials Incorporating Au

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Materials with confined structures have attracted much research, especially metal oxides incorporating metal nanoparticles that are potentially useful for applications including catalysts, photocatalysts, solar cells etc. If nanoporous metal oxides can be prepared by a straightforward route, it is possible to improve the catalytic activity for their high surface area, and such material will find broad applications. Here we describe an approach to prepare $In(OH)_3$ and In_2O_3 nanomaterials with rectangular shape.

In a typical experiment, $In(OH)_3$ nanocubes were preparation of dissolving $InCl_3$ in base solution under hydrothermal condition and nanoporous In_2O_3 were obtained on calcination of as-synthesis of nanocubes $In(OH)_3$ at a temperature 450 °C. Nanoporous $In(OH)_3$ and In_2O_3 exhibit white and light yellow colors, respectively (**Figure 1a.**).

The thermal decomposition of $In(OH)_3$ nanocubes were investigated on a powder sample with synchrotron X-ray powder diffraction (NSRRC BL01C) for various temperatures in the range 25 – 500 °C; the results appear in **Figure 1b**. Only peaks attributed to the $In(OH)_3$ (JCPDS Card No. 85-1338) was observed at room temperature. Respectively, The broad diffraction peak of each compounds were confirms that the as-synthesized sample contains $In(OH)_3$. A transition from $In(OH)_3$ to the In_2O_3 phase is observed when the temperature was above 400 °C, indicative of the transformation of theIn$(OH)_3$ toIn$_2O_3$ and without any residual peaks of byproduct. The morphology of $In(OH)_3$ and In_2O_3 were further characterized using scanning/transmission electron microscopy (SEM/TEM). The TEM image of the $In(OH)_3$ sample shows nanocrystals of rectangular shape with average edge length 60 nm. The selected-area electron diffractions (SAED) exhibit [001] zone-axis diffraction of bcc $In(OH)_3$, indicative of a single-crystalline product (**Figure 2a.**).

After complete decomposition at 450 °C, the $In(OH)_3$ nanocrystals of rectangular shape were fully transformed into In_2O_3 with analogue morphology. However, transmission electron microscopy (TEM) images were revealed the distinctive, nanoporous feature of In_2O_3 nanocomposites. TEM image of an In_2O_3 particle of rectangular shape exhibits a highly porous morphology formed by interconnected indium-oxide nanocrystals with average pore diameter 3-5 nm (**Figure 2b.**). The wall thickness is about 5 nm for most aggregated rectangular nanoporous samples. The fine structure of a small domain exhibits a lattice fringe of spacing 0.29 nm, in agreement with the *d* value of (222) planes of the cubic In_2O_3 structure. Selected-area electron diffraction (SAED) pattern of nanoporous In_2O_3 was indexed to cubic In_2O_3. The diffraction rings and dots revealed that nanoporous In_2O_3 was polycrystalline, and which was composed small In_2O_3 nanocrystals.

Conclusion

In summary, $In(OH)_3$ and In_2O_3 nanocrystals of rectangular shape have been successfully prepared using a hydrothermal reaction followed by thermal decomposition. This method provides a route to synthesize $In(OH)_3$ and In_2O_3 nanostructures with a well controlled internal structure. This procedure will be readily generalized to prepare other nanoporous metal-oxide materials and expected to serve as catalyst, gas sensor, and quantum-dot solar cell substrate; these applications are currently under investigation.

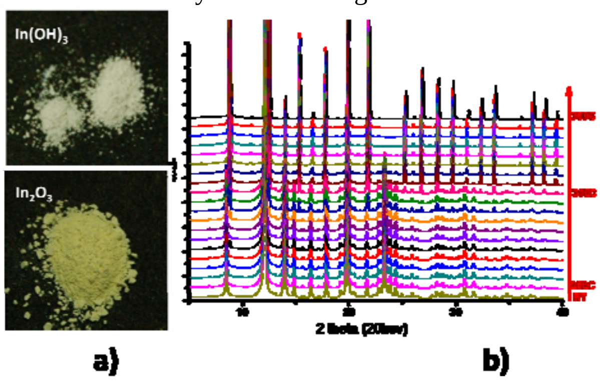

Figure 1. a) The color of $In(OH)_3$, In2O_3 powder samples. b) Temperature-dependent synchrotron powder diffraction patterns of $In(OH)_3$.

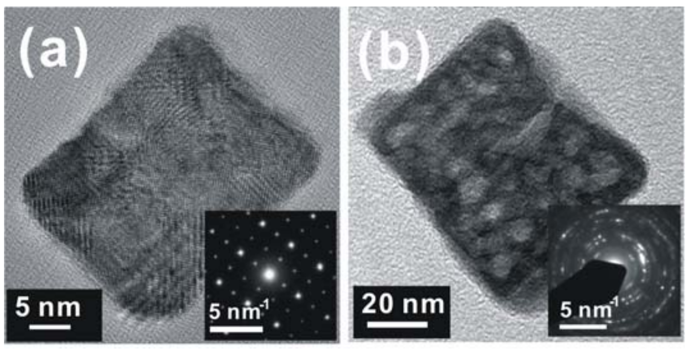

Figure 2. TEM images and corresponding SAED patterns (insets) of a) $In(OH)_3$, b) In_2O_3