

Characterization of Tungsten Oxide Nanomaterials Prepared by a Plasma Arc Gas Condensation Technique

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Due to the unique properties, tungsten oxide (WO_{3-x} , $0 < x < 1$) nanomaterials have been widely investigated for the past decades. Among these tungsten oxide nanomaterials, one-dimensional (1D) tungsten oxide exhibiting distinctive morphologies have been developed. In the present study, tungsten oxide nanomaterials with various size and shape were synthesized by a plasma arc gas condensation technique by appropriately controlling processing parameters. For instances, equiaxed tungsten oxide nanoparticles and nanorods can be synthesized respectively. A rapid growth along [001] direction was preferred when large plasma current was used and induced superfluous amount of tungsten oxide and formation of W_5O_{14} nanorods can be achieved. Figures 1(a) and 1(b) show the tungsten oxide nanoparticles and nanorods respectively. Meanwhile, when a dual target consisting of tungsten and anatase TiO_2 raw materials was used, core-shell $\text{WO}_{3-x}\text{-TiO}_2$ powders were synthesized, Fig. 1(c).

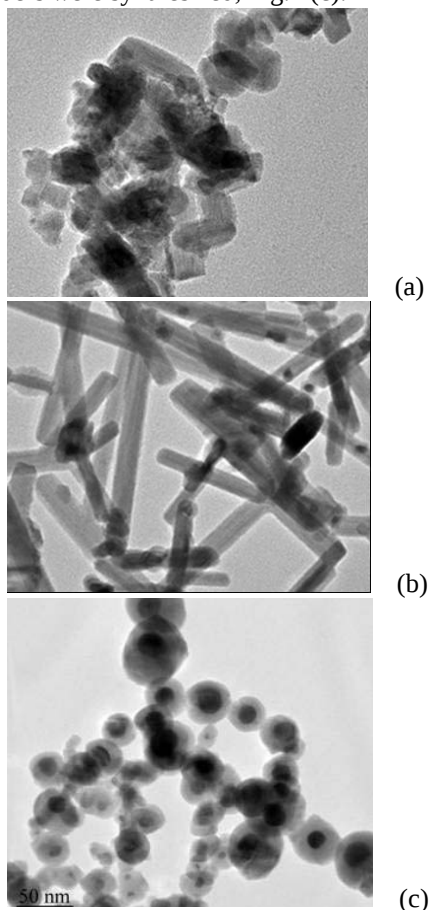


Figure 1. TEM images of nano-sized tungsten oxide

(a) particles, (b) rods, and (c) core/shell powders.

Synchrotron X-ray absorption spectroscopy studies was used to evaluate these tungsten oxide nanomaterials. Figure 2 shows some of the XANES spectra of these tungsten oxide nanomaterials, where relative peak shift due to differences in the valence of tungsten can be noticed. Though not shown here, the XANES spectra of the core/shell nanopowders examined at Ti K edges also revealed differences. A transition from anatase to rutile phase TiO_2 can be noticed.

It is also interesting to note that, even tungsten oxide nanomaterials exhibiting the same phase of W_5O_{14} , tungsten oxide nanomaterials may exhibit slight differences in electronic properties. Figure 3 shows a series of W_5O_{14} nanomaterials with different aspect ratios (from equiaxed nanoparticle to nanorods) when examined by XANES at oxygen K edge. The slight differences in electronic properties induced different gas sensing performance of these tungsten oxide nanomaterials.

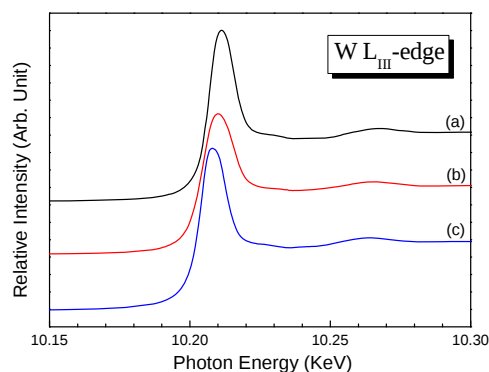


Figure 2. XANES spectra of (a) Tungsten oxide/titania core shell powders, (b) tungsten oxide powders, and (c) tungsten oxide nanorod.

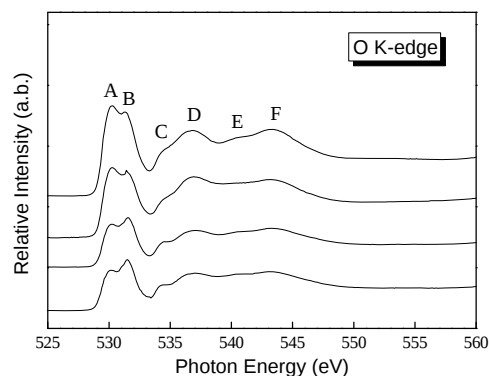


Figure 3. XANES spectra at O K edge for tungsten oxide nanomaterials.