NOVEL POLYMER-METAL PRECURSOR ROUTE FOR SIMPLE AND MASS PRODUCTION OF ITO NANOPARTICLES

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Sn-doped In_2O_3 [indium tin oxide (ITO)] is a promising type of transparent conducting oxide material, and has been used in wide fields such as optoelectronic devices, solar cells, liquid crystal displays and sensors.[1] Over the past decades, much research effort has been made on the synthesis of ITO films. Several effective techniques have been reported to obtain these coatings including d.c. magnetron sputtering,[2] highly dense plasma assisted electron beam evaporation,[3] and sol–gel method.[4] These films may also be prepared by dispersing ITO nanoparticles with desirable optical properties in a polymer binder. For these applications, small particle size or large specific surface area is essential to high performance. In this work, we describe the synthesis of monodisperse ITO nanoparticles less than 20nm in average particle diameter in mass production through novel simple two-step method using the coordinating chemistry between the electron donating polymeric ligands and the metal ion, which offers several advantages over other methods, including simple procedure, lower processing temperature, and better homogeneity. We have proceeded to the measurement of physico-chemical properties such as surface area, particle characteristics, crystal structure and etc. of ITO nanoparicles that were prepared by this novel synthetic method.

The synthesis of ITO nanoparticles was carried out by simple scheme in Figure 1, which contains the mixing of 10 wt % and 5 wt % PEO solutions and In and Sn compounds such as $In(NO)_3 \cdot 3H_2O$, $In(Ac)_3$, $SnCl_2 \cdot 2H_2O$, or $Sn(C_2O_4)$, then followed by thermal decomposition at 450 , and 600 , respectively, where the molar ratio of metal precursor was 9:1(In/Sn) and that of PEO monomer was 1:1 to moles of total metal ions. The morphologies of the nanoparticles were observed using a Hitach H-7600 transmitted electron microscope (TEM) under an acceleration voltage of 100kV. The XRD patterns were obtained from the X-ray diffractometer (Rigaku D/MAX-2500, 18kV) using Cu $K_{\alpha 1}$ radiation (λ = 1.5405 Å). Nitrogen adsorption-desorption isotherms were collected at -196 °C using Micromeritics ASAP 2020 equipment. Figure 2 displays the experimental XRD patterns of the ITO samples. Except for the difference in intensities, the as-synthesized ITO nanoparticles were highly crystalline and all the diffractograms correspond to the cubic bixbyite structure of indium oxide(ICDD PDF No. 6-416) without any indication of crystalline SnO_2 as an additional phase. This observation points to the formation of solid solutions rather than the mixture of indium oxide and tin oxide. On the other hands, the morphologies of ITO nanoparticles appeared to be a little different in size according to the average molecular weight of PEO (Figure 3) and thermal decomposition temperature. It may be understood due to the difference of coordination length in metal-polymer precursor. And it will be discussed in relation with other physico-chemical properties such as specific surface area and so on.

References:

[1] I. Hambergend and C. G. Granquist, *J. Appl. Phys., 60*, R123 (1996); B. J. Luff, J. S. Wilkinson, and G. Perrone, *Appl. Opt., 36,* 7066 (1997).
[2] H. Morikawa, M. Fujita, *Thin Solid Films, 359*, 61, (2000).
[3] I.A. Lauf, *Mater. Lett., 18* 123, (1993).
[4] T.F. Stoica, V.S. Teodorescu, M.G. Blanchin, T.A. Stoica, M.Gartner, M. Losurdo, M. Zaharescu, *Mater. Sci. Eng., B101*, 222, (2003).

Figures:

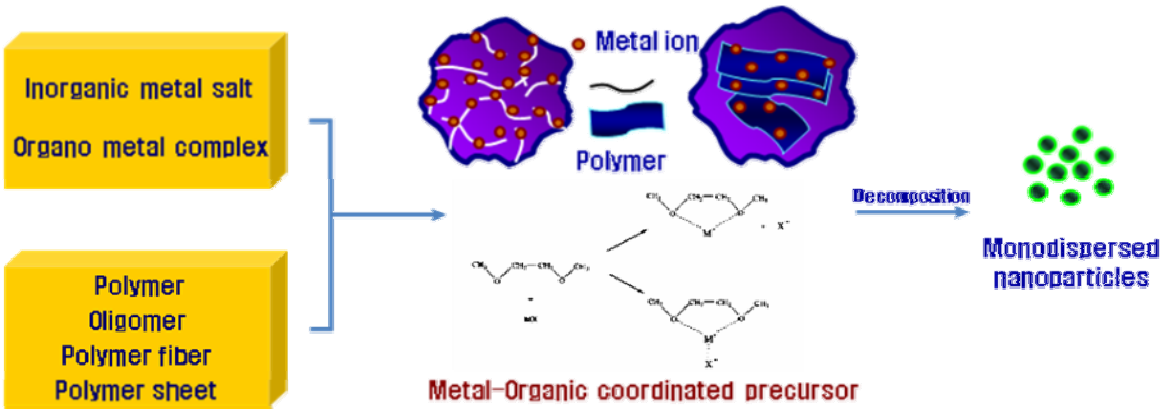


Figure 1. Schematic representation of this synthetic strategy.

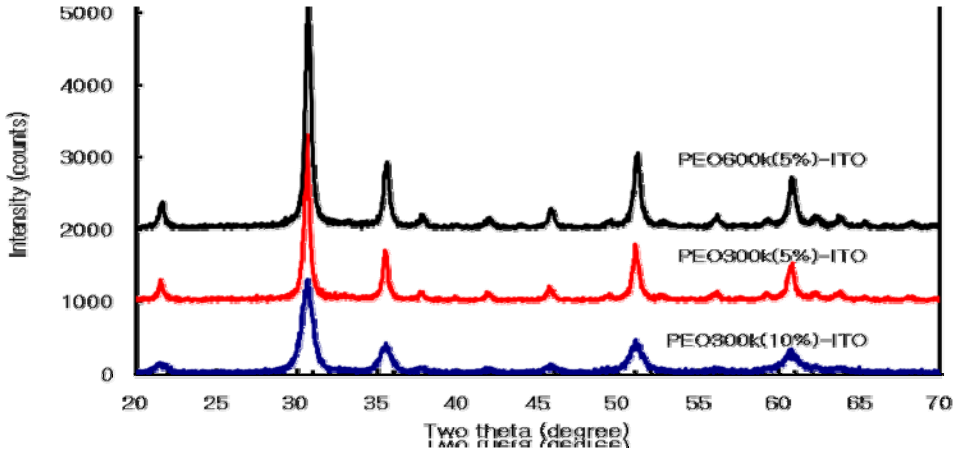
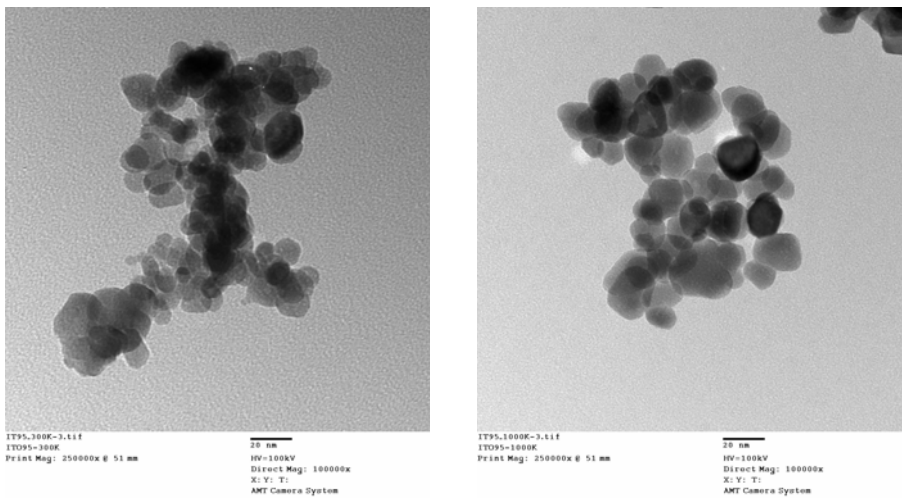


Figure 2. XRD patterns of the ITO nanoparticles according to the synthetic conditions.



(a) (b)

Figure 3. TEM images of the ITO nanoparticles synthesized with PEO of different average molecular weight : (a) M.W. 300,000 and (b) M.W. 1,000,000