Synthesis and Characterization of highly reproducible Zinc Oxide nanorods and their photocatalytic efficiencies

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Abstract: The synthesis, microstructural characterization and photocatalytic activity of ZnO nanorods grown onto a buffer TiO_2 film coated borosilicate glass substrates, were evaluated. Samples were analyzed in order to confirm the crystallinity, chemical composition and morphological reproducibility of the structures and later used to evaluate their photocatalytic ability to degrade an organic dye. Differences among samples were noticed from microstructural analysis. As a result, optical properties were affected and consequently their photocatalytic performance presented some minor fluctuations.

Keywords: photocatalysis, ZnO nanorods, AACVD.

1. Introduction

One-Dimensional structures as nanorods and nanowires are desired morphologies for many applications, such as photocatalysis [1] or solar cells [2], as they provide a higher surface-to-volume ratio, increasing the amount of active material for a given process [2]. ZnO can be obtained in a wide range of morphologies [2]; it has exhibited efficient photocatalytic performance when used to degrade organic pollutants. However, a number of factors including crystalline phase, shape, size and orientation [1] play an important role in material performance. According to previous information, this work focuses on the synthesis and characterization of ZnO nanorods obtained by aerosol assisted chemical vapor deposition (AACVD) in similar configuration as in [3], in order to establish differences caused due to synthesis process.

2. Experimental

Four different samples were synthesized by AACVD during different periods of time, in order to estimate materials reproducibility and possible properties variations due to synthesis process and ambient conditions. Samples consisted of ZnO nanorods grown over TiO_2 thin film coated borosilicate glass substrates and were named consecutively as TZ1, TZ2, TZ3 and TZ4. The microstructure of the bi-layered coatings was characterized by grazing incidence X-ray diffraction, scanning and transmission electron microscopy. Elemental composition and chemical species were studied by X-ray energy dispersive and photoelectron spectroscopy, respectively. Optical properties were determined from transmittance and reflectance measurements. The photocatalytic property was evaluated by methylene blue (MB) solution discoloration when placed in contact with the material for 60 minutes. Samples were kept inside a radiation chamber and irradiated under two distinct light sources: a UV black lamp and a Fluorescent white lamp.

3. Results and discussion

Crystalline structure determined from GIXRD exhibited the presence of ZnO and TiO_2 as wurtzite and anatase phases, respectively. Components of the resulting oxides were detected by XPS and also, the elemental distribution of the constituents observed by depth analysis showed the chemical purity of the materials and their reproducibility.

Secondary electron SEM micrographs are shown in Fig. 1. They exhibit the characteristic columnar and polygonal structure of ZnO nanorods. All cases (not all shown) evidenced the similarities among the samples, except for nanorods in Fig. 1 (a), from where the apparition of a sharp tip at the end of the columns was observed and also, a non-uniform length of the material was noticed and was evident on insets for these micrographs. Variations could be attributed to changes in ambient temperature or pressure as the synthesis process is carried at room conditions.

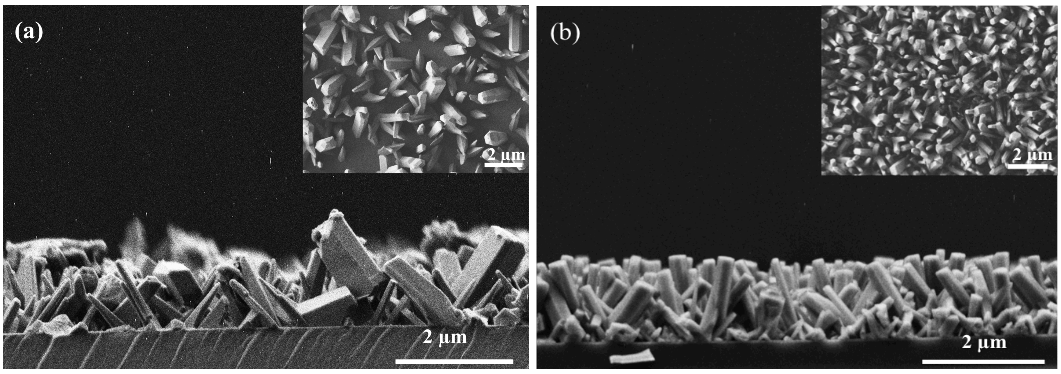

Figure 1. Micrographs corresponding to samples: a) TZ1 and b) TT2.

Absorbance spectra obtained from total reflectance and transmittance measurements exhibited variations in materials response as seen in Fig. 2 (a). Samples with similar diameter (TZ1-TZ3 and TZ2-TZ4) exhibited differences mostly in UV-VIS interval. The effect could be attributed to variations in shape, due to the formation of sharp nanorods and to the apparition of long and short structures covering the substrate (sample TZ1). An average of the several photocatalytic tests is presented in Fig. 2 (b) and indicated that all materials exhibited high MB discoloration values (71 to 92% and 91 to 99%) under fluorescent and UV-A light sources. As expected from Fig. 2 (a), discrepancies in photocatalytic activity were more evident within the use of a fluorescent lamp, whose qualitative active spectra is in the UV-VIS region.

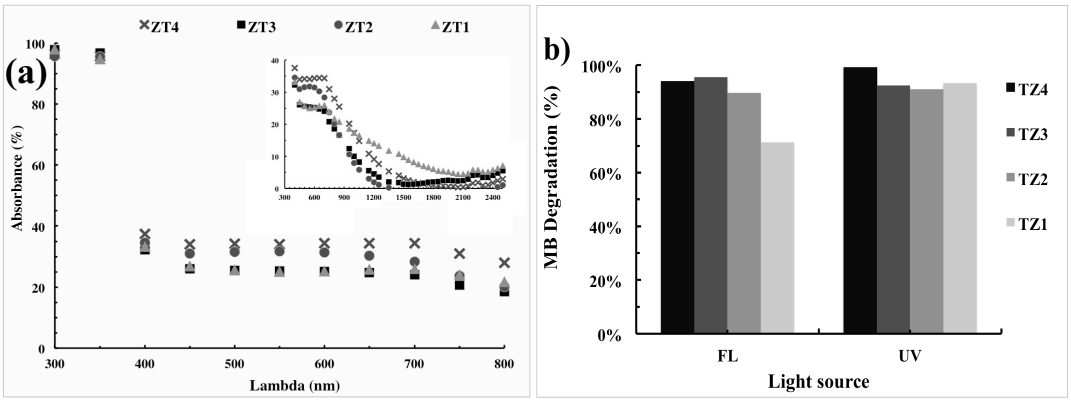

Figure 2. Showing: a) samples absorbance and b) the average percentage of Methylene Blue discoloration reached.

4. Conclusions

Results indicated that variations presented during the synthesis had influence on samples morphology, visible as changes in size, shape and uniform distribution of the material on the substrate, as clearly observed in SEM analysis. No significant repercussions were detected in chemical composition obtained by XPS or crystalline structure by GIXRD, but they were seen in optical properties. The later, affected the photocatalytic response of the material mostly in the UV-VIS interval.

References

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