

Physico-Chemical and Electrocatalytic Properties of Nanostructured TiO₂-Pt Thin Films

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Titanium dioxide (TiO₂) is not only of great interest at the fundamental level but for a wide range of electroanalytical applications. Indeed, innate chemical-physical properties such as, excellent chemical stability and compatibility with several substrates, thermal stability, biocompatibility, non-toxicity and economical advantages such as low cost, and low temperature processing possibilities, make TiO₂ as one of the most actively investigated material. Because of these diverse properties each of which allows TiO₂ to be of interest such as catalyst support for fuel cells electrodes, anode material for photovoltaic energy systems, corrosion-resistant support, anode material for lithium-ion batteries, supercapacitors, and bioelectrochemical sensors, to name few.

In this study, a series of nanostructured thin films of TiO₂ were prepared at room temperature by pulsed laser deposition (PLD) technique. Three different background atmosphere, namely, vacuum, He, and O₂ were used in order to obtain deposits of different morphology and microstructure. Pt nanocatalyst was afterward deposited by PLD onto the TiO₂ layers. Scanning electron microscopy (SEM), energy-dispersive X-ray (EDX), atomic force microscopy (AFM), Transmission electron microscopy (TEM), micro Raman spectroscopy, X-ray diffraction (XRD), and X-ray photoelectron spectroscopy (XPS) techniques were employed to characterize the deposits.

Cyclic voltammetry (CV) and chronoamperometry were employed to study the electrocatalytic properties and durability of thus synthesized TiO₂/Pt samples towards ethanol electro-oxidation, reaction that is of fundamental significance to direct ethanol fuel cells (DEFCs).

Examples of some deposits are shown in SEM and AFM images of Fig. 1 and 2, respectively. TiO₂ deposited onto an electrically conductive 3-D network of carbon microfibers (CMF) substrate is shown in Fig. 1a, where it can be seen that the latter is highly and uniformly decorated with a rough TiO₂ layer fashioned into regular segments made of clusters of particles with the presence of grain boundaries. Fig. 1b shows that the underlying TiO₂ film (no more visible) is greatly and homogeneously coated with a Pt deposit recalling the texture of cauliflower. The AFM images of TiO₂ (Fig. 2a) and Pt (Fig. 2b) confirmed that both deposits are made of an ensemble of small particles that followed a columnar growth.

Figure 3 compares CVs run with 5 mV/s in 1 M C₂H₅OH+ 0.5 M H₂SO₄ deaerated solution at TiO₂/Pt and carbon nanotubes (CNT)/Pt electrodes. Both electrodes exhibited well defined ethanol electrooxidation features. However, the electroactivity of TiO₂/Pt electrode outperformed that of CNT/Pt electrode. Indeed, the CVs reveal that the onset oxidation potential of ethanol is 197 mV negative at the TiO₂/Pt electrode and the current peak density is 2.3 greater than the one delivered by the CNT/Pt electrode.

Such results open new perspective towards the

development of catalyst support alternative to carbon in fuel cells systems. More physico-chemical properties of various Pt based-TiO₂ structures and their prospective use as ethanol fuel cell anodes will be reported at the meeting.

Acknowledgements

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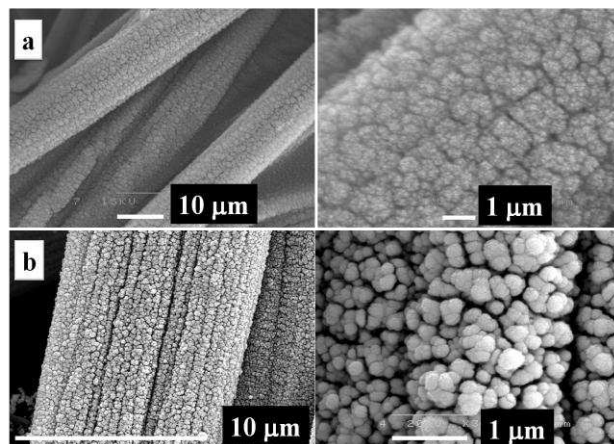


Fig. 1 SEM images of room-temperature PLD-deposited films: (a) TiO₂ and (b) Pt.

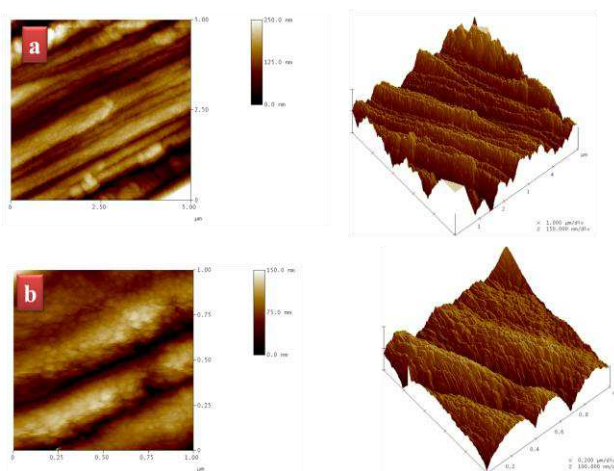


Fig. 2 AFM images of room-temperature PLD-deposited films: (a) TiO₂ and (b) Pt.

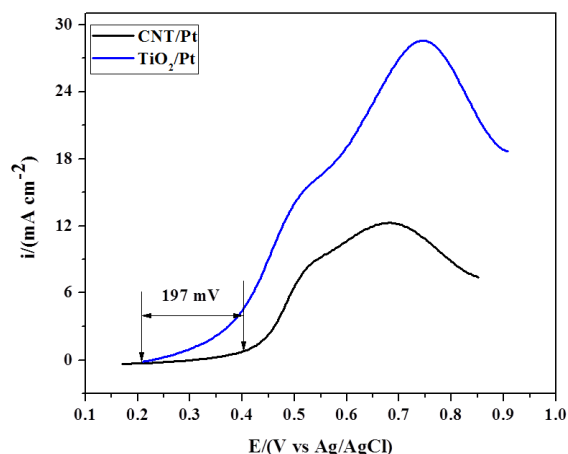


Fig. 3 Cyclic voltammograms recorded in 1 M C₂H₅OH+ 0.5 M H₂SO₄ deaerated solution at a scan rate of 5 mV/s. CNT/Pt (black curve) and TiO₂/Pt (blue curve).