

Fabrication of the Titanium dioxide nanowires on the FTO substrate and evaluating the efficiency power conversion in the dye-sensitized solar cell

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ABSTRACT:

The present work involves fabricating TiO₂ nanowires on the fluoride doped Tin oxide glass substrate by the hydrothermal method to use as photoelectrode in the dye-sensitized solar cell together with a counter graphene nanoplatelets. The morphology and structure of TiO₂ nanowires were characterized by the scanning electron microscopy, X-ray diffraction, and energy dispersive X-ray spectroscopy. The results emphasized the synthesis of it on the FTO at the optimum conditions such as degree of temperature and reaction time. The photovoltaic parameters estimated and the solar cell showed the fill factor close to 0.304 under irradiated with a light source at 85 mW/cm².

KEYWORDS: DSSC's, nanowires, graphene, nanoplates, TiO₂ NWs, fill factor.

1.1 Introduction

The dye-sensitive solar cells have taken a great deal of interest because of their advantages such as low cost and wide source. Their design is relatively easy and least energy consumption. It consists of transparent conductive glass and photoanode, which is an important part in determining the performance of DSSCs, dyes, electrolyte, and electrode (Hu, Liu, Chen, Li, & Yang, 2017). The possession of nanomaterials for a high surface area made their interfaces play an important role in the photovoltaic performance of dye-sensitive solar cells and in determining their physical characteristics (Birkel et al., 2012). Titanium dioxide is one of the most hopeful candidates because of its prominent properties, such as its light absorption power, chemical inertness and steadiness. One-dimensional nanomaterials such as nanowires, nanotubes and nanofibers have been produced in various ways such as sol-gel method, template method, anodic oxidation and hydrothermal method to improve the performance of dye-sensitized solar cells (Matsuda, Sreekantan, & Krengvirat, 2013). The One - dimensional titanium dioxide nanowire arrays film compared to titanium dioxide nanoparticle mesoporous membrane, which leads to insufficient dye adsorption, and thus depressed light-harvesting performance. So as to increase the internal surface area, the oriented hierarchical TiO₂ NWs arrays were prepared by researchers (Bapu & Yusuf, 1993). An else practical way to enhance dye adsorption then lastly enhance the power transformation efficiency of DSCs is to exceed the length of nanowire arrays (Kanta, Poelman, & Decroly, 2015). So, in the present research we synthesis Titanium dioxide nanowires by designing a new set of hydrothermal to achieve on FTO glass and fabrication a new dye-sensitized solar cell with graphene nanoplates as a counter and performance the conversion efficiency of electrical energy.

1.2 EXPERIMENTAL PART

Firstly, the glass (FTO) was ultrasonically cleaned in both acetone, iso-propyl alcohol and deionized water sequentially for 15 minutes (Ye et al., 2014). Titanium dioxide nanowire is prepared by adding 1 ml of titanium (IV) butoxide to a mixture of deionized water and hydrochloric acid by 12:12 drop wise to obtain a clear transparent solution. The solution is then transferred to the autoclave. Where the glass fluoride doped tin oxide is placed at an angle in the autoclave and heated to a temperature 180°C for 3 hours as shown in figure 1.



Figure 1: preparation of TiO₂ NWs

Also, to prepare the counter electrode of DSS, we weigh a 0.01 gram of graphene nanoplatelets (GNP) suspension in 50 ml of deionized water and sonication for 15 min. After that, the FTO glass cleaned in a solvent (acetone and ethanol 2:4) and aqueous solutions in the sonication bath for 10 min. and dry by the nitrogen gas and then radiation by the U.V light source to enhance the adhesive the graphene nanoplatelets on the substrate through the electrophoretic method with applied 10 volts for the 90s. After this time, cleaned the CE by immersing it in deionized water to remove the residual of uncoated graphene nanoplatelets molecules, and checked the conductivity "resistance" of all surface to inspect to cover whole the surface by the GNP through selected a suitable point on it to measure.

After that, the immersion of thin film that coated on the FTO glass in 5×10^{-4} M of N3dye in acetonitrile at room temperature for 24 h. The counter electrode of graphene nanoplatelets (GNP) on ITO glass collects with the photoanode and fill up by the electrolyte included "0.5 M N-methyl-N-butyl-imidazolium iodide (BMII) + 0.1 M LiI + 0.05 M I_2 + 0.5 M 4-tert-butylpyridine" (TBP) in acetonitrile. The last step after the injection of electrolyte between two electrode performance of the DSSCs while the solar cells were irradiated with a light source at 85 mW/cm^2 .

1.3 : Results and Discussion

From the figure 2, the XRD data show an excellent agreement with the standard rutile structure of TiO_2 (PDF card- TiO_2 -00-021-1276) the main peak centred (J. H. HU ET AL., 2016) at 27.5022° can be ascribed to the (110) facet of Rutile TiO_2 , The absence of any peaks for other impurities is proof of the high purity of the product .

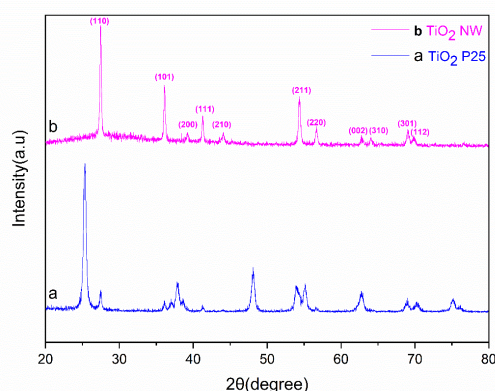


Fig. 2 The XRD patterns of TiO_2 P25 and (a) as-synthesized TiO_2 NW arrays (b).

Figure (4 a,b,c,d) shows SEM images the top surface of the nanowire at different magnification forces. It has the high order and the nanowire arrays can be seen densely packed on the FTO glass substrate, as nanowire has tetragonal crystallographic levels and the side profile images show a nanowire arrangement vertically on the glass surface and the length of the nanowire is around $5.17 \mu\text{m}$. (3-23 e) shows a quantitative analysis of the EDX spectra. It is illustrated the presence of oxygen and titanium elements which can be taken as evidence of existence TiO_2 NW's.

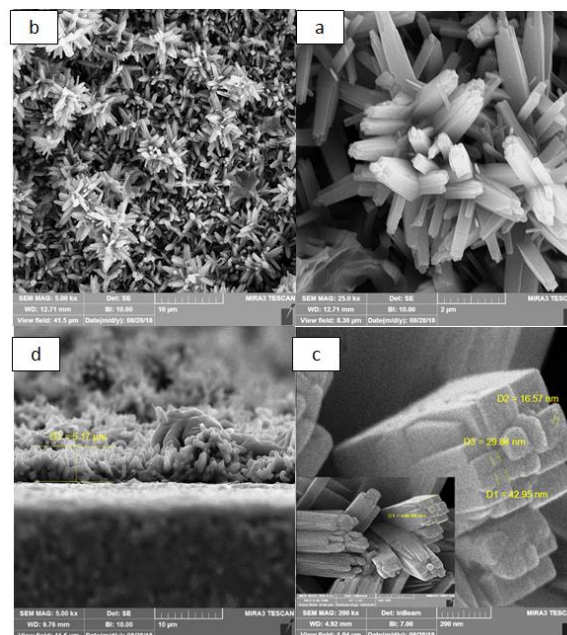


Fig 3: Shows SEM images of TiO_2 nanowire (a, b) Top morphology and (c, d) scale of diameter and (e) cross-section (f) EDX spectrum

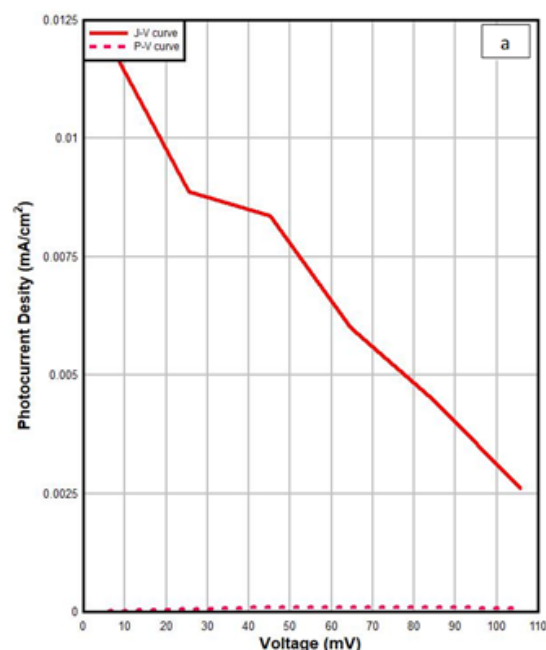


Figure 4: photocurrent-voltage curve and power of TiO_2 nanowire prepared at 3 hours (a)

Figure 4 shows the photocurrent voltage curve obtained by using titanium dioxide nanowire as a photoanode prepared with different time, Voc of TiO₂ NW at prepared 3 hours. The photocurrent-voltage parameters such as open circuit voltage (Voc), short circuit current density (Jsc), Voltage at max power point (Vmpp), current at max power point (Impp), fill factor (FF) and cell conversion efficiency (η) as well series resistance (Rs) and shunt resistance are estimated from the J-V curves a tabulated in Table 1.

V_{oc} / V	$J_{sc} / \text{mA/cm}^2$	V_{mpp} / V	I_{mp} / mA	FF	η	R_s / Ω	R_{sh} / Ω
0.142	0.012	0.064	0.008	0.227	0.0006	85271.11	666487.04

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