Preparation and Characterization of WO_3 Films on FTO Glass for Optimizing Photoelectrochemical Cell Performance

Daisy Li, Favor Igwilo, Qamar Hayat-Khan, Benjamin Sherman

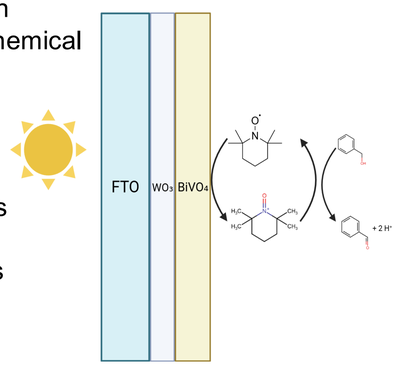
Texas Christian University, department chemistry and biochemistry , TX 76109 USA

1. Introduction

WO_3 films can enhance the efficiency of photoelectrochemical cells, which are critical for sustainable energy production such as solar water splitting.

WO_3 electrode can be used as the base layer to make FTO-WO_3-Bismuth Van($BiVO_4$)-Nickel Oxide (NiO) electrode ,which has the potential to improve the photochemical performance in photoelectrochemical cells.

Investigating how WO_3 interacts with other materials could lead to advancements in energy applications.

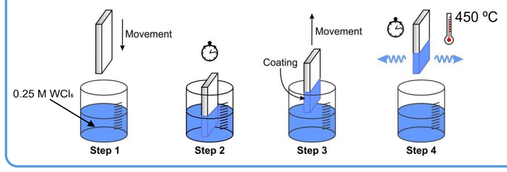


2. Objectives

- To successfully prepare a single-layer tungsten oxide (WO_3) film on fluorine-doped tin oxide (FTO) coated glass
- To explore the electrochemical and structural properties of the WO_3 films.
- Future work will investigate the interaction of WO_3 with nickel oxide (NiO) and bismuth vanadate ($BiVO_4$) for improved photoelectrochemical cell performance.

3. Methods

In this work, a single-layer tungsten oxide (WO_3) film on fluorine-doped tin oxide (FTO) coated glass was prepared by the dip-coating method.0.98 g of WCl_6 is added to 10mL EtOH to make the 0.25 M highly saturated precursor solution[1], followed by thermal treatment at 450 ºC indicated below [2].



Results

The structure and electrochemical properties of the WO_3 film can be determined via UV-Vis spectroscopy, and transient photocurrent measurement such as Cyclic Voltammetry and chronoamperometry .

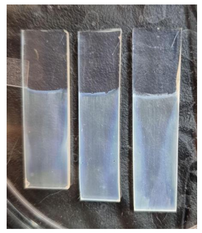


Figure 1. WO_3 on FTO glass

A) Cyclic Voltammetry

All the cyclic voltammetry graphs showed a positive correlation between scan rate and current density. By comparing Figures 2 and 3, we can see that the current density of FTO|WO_3 without light is lower than that with light. For Figures 2 and 3, there is an obvious peak around 0.2 V, possibly due to the presence of tungsten oxide.

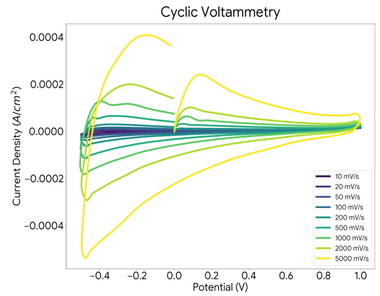


Figure 2 Cyclic voltammetry of FTO|WO_3 electrode in the presence of 5 mM TEMPO and in 100 mM $TBAPF_6$ with light

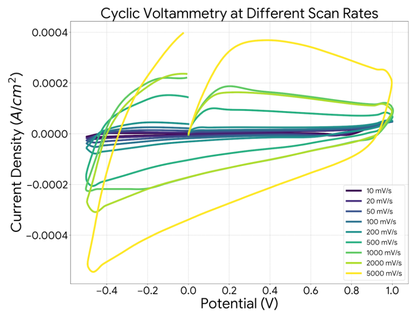


Figure 3 Cyclic voltammetry of FTO|WO_3 electrode in the presence of 5 mM TEMPO and in 100 mM $TBAPF_6$ without light

B) UV-Vis Spectroscopy

As shown in Figure 5, the graph exhibits a strong absorption peak around 380 nm, suggesting the presence of tin oxide. This peak is absent in Figure 4, likely due to the tungsten oxide layer masking the tin oxide signal.

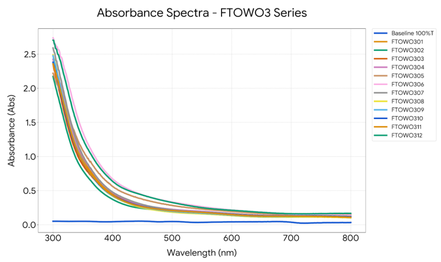


Figure 4 Absorbance spectrum graph of WO_3 on FTO glass

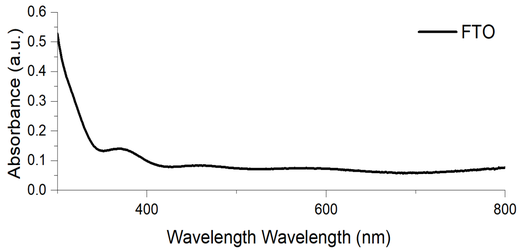


Figure 5 Absorbance spectrum graph of FTO glass

Results

C) Chronoamperometry

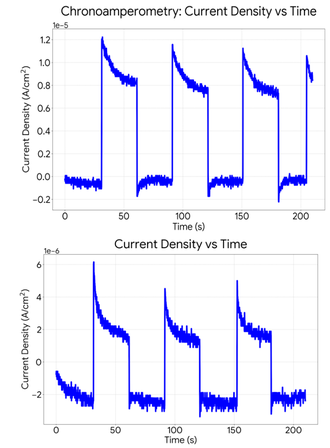


Figure 6. Cyclic amperometry of WO_3/FTO in electrolyte containing 5 mM TEMPO in 100 mM $TBAPF_6$ at 0.8 V vs. Ag/Ag^+ (Top), Cyclic amperometry of WO_3/FTO in electrolyte containing 5 mM TEMPO in 100 mM $TBAPF_6$ at 0.6 V vs. Ag/Ag^+ (bottom)

Conclusions

- The fabrication of WO_3 films on FTO glass was successful with significant improvements in film quality and uniformity observed in later trials.
- UV-Vis results confirm the successful formation of WO_3 on FTO glass.
- The photoelectrochemical data confirm that tungsten oxide is active under 1 sun illumination, and the addition of TEMPO significantly increases the current density

Future work

- Further investigation of the interaction between WO_3, NiO, and $BiVO_4$ layers for enhanced photochemical performance.
- Detailed structural analysis via XRD to explore crystal structure.

Reference

(1) McMillan, N. K.; Wortley, J.; Nguyen, K.; Lopez, D. A.; Leem, G.; Sherman, B. D. ACS Appl. Eng. Mater. 2023, 1 (11), 3122–3133.

(2) Frederichi, D.; Scaliante, M. H. N. O.; Bergamasco, R. Environ. Sci. Pollut. Res. 2021, 28 (19), 23610–23633.