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

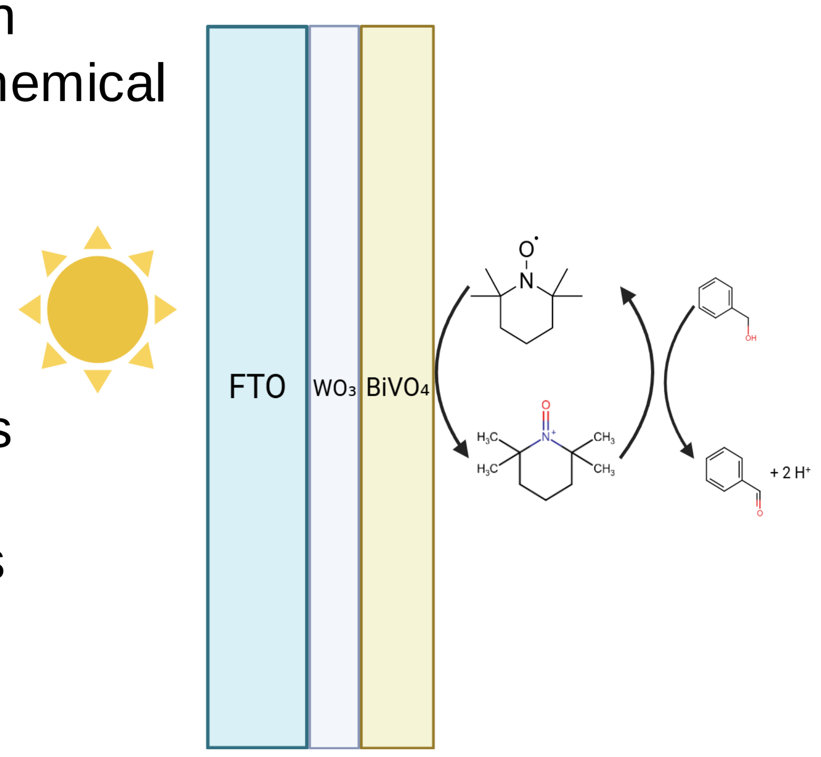
Daisy Li, Favor Igwilo, Ines Soto, Qamar Hayat-Khan, Benjamin Sherman
Texas Christian University, department chemistry and biochemistry , TX 76109 USA

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.

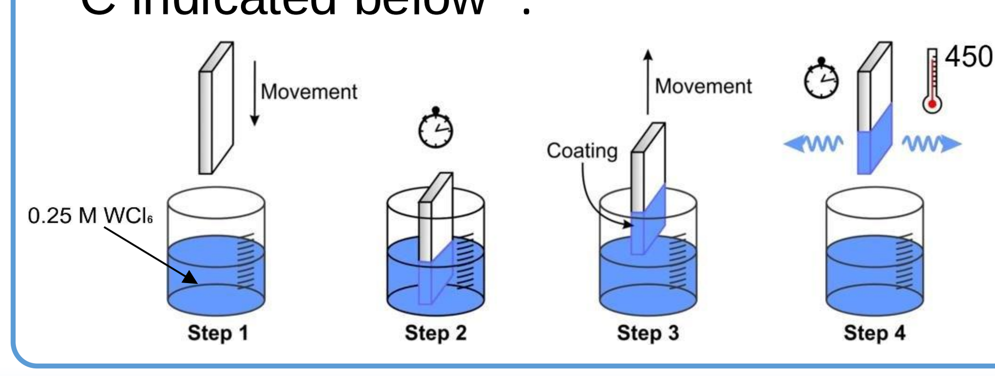


2. Objectives

- 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].

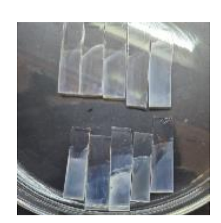


Results

The structure and electrochemical properties of the WO_3 film can be determined via surface profilometry, UV-Vis spectroscopy, and transient photocurrent measurement.

A) Film appearance and observations

Table 1: Experimental result and data for FTO| WO_3

Trial	Date	Image	Appearance	Key Observations	Average Thickness(µm)
1	1/23/25		white, slightly yellow	6 samples with typical FTO behavior, samples are varying in absorbance, with a characteristic absorption peak around 380 nm.	0.17(7)
2	1/30/25		white, uneven with uneven precipitation	5 samples with typical FTO behavior, samples are less varied in absorbance compared to the first trial, with a characteristic absorption peak around 380 nm.	0.10(9)
3	2/13/25		white with uneven precipitation	10 samples with typical FTO behavior, samples vary in absorbance, with a characteristic absorption peak around 380 nm.	N/A
4	2/20/25		white, even layer	10 samples with typical WO_3 behavior, samples are varying in absorbance with no visible peaks.	0.18(8)
5	2/26/25		white, even layer	10 samples with typical WO_3 behavior, samples are less varying in absorbance compared to trial 4 with no visible peaks.	0.079(5)

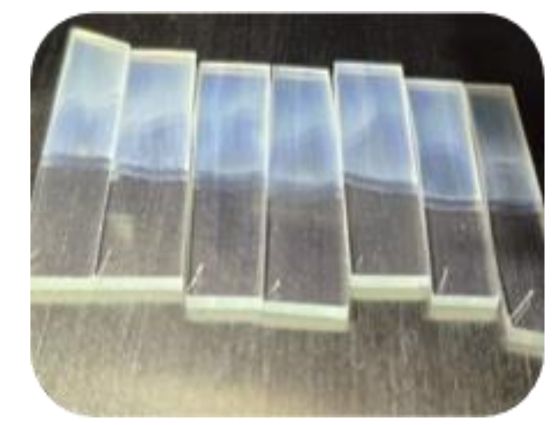


Figure 1. WO_3 on FTO glass

The data collected over the course suggest improvements in the preparation procedure, quality of materials, and dipping technique used for making WO_3 films on FTO glass.

B) UV-Vis Spectroscopy

As shown in Figure 3, the graph exhibits a strong absorption peak around 380 nm, suggesting the presence of tin oxide. This peak is absent in Figure 2, likely due to the tungsten oxide layer masking the tin oxide signal.

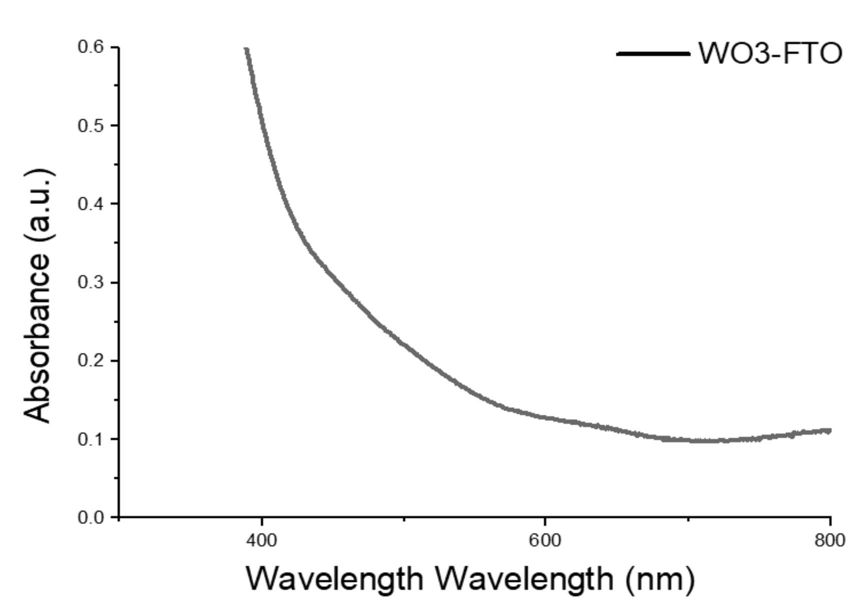


Figure 2 Absorbance spectrum graph of WO_3 on FTO glass

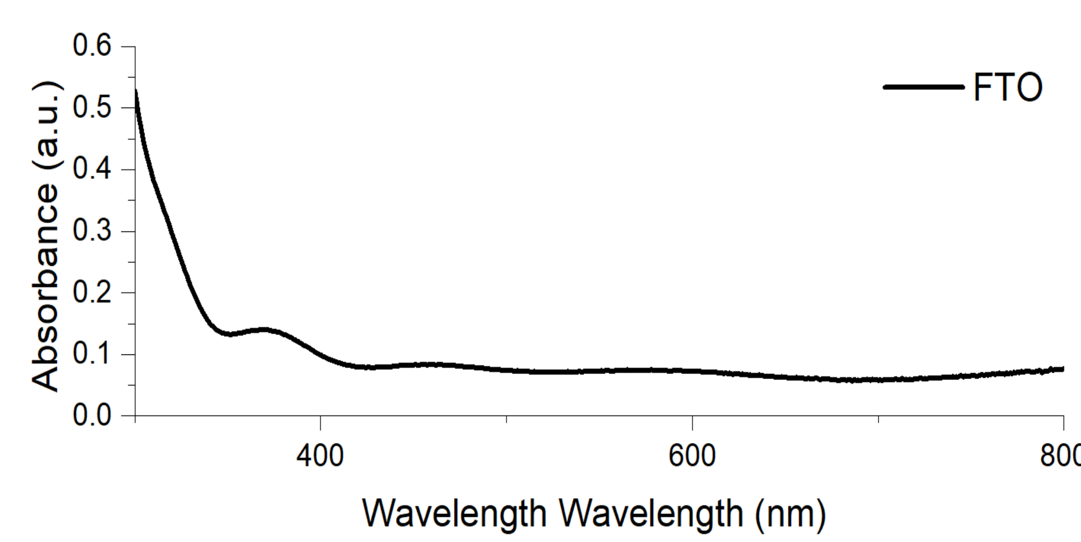


Figure 3 Absorbance spectrum graph of FTO glass

Results

C) Electrochemical Measurements

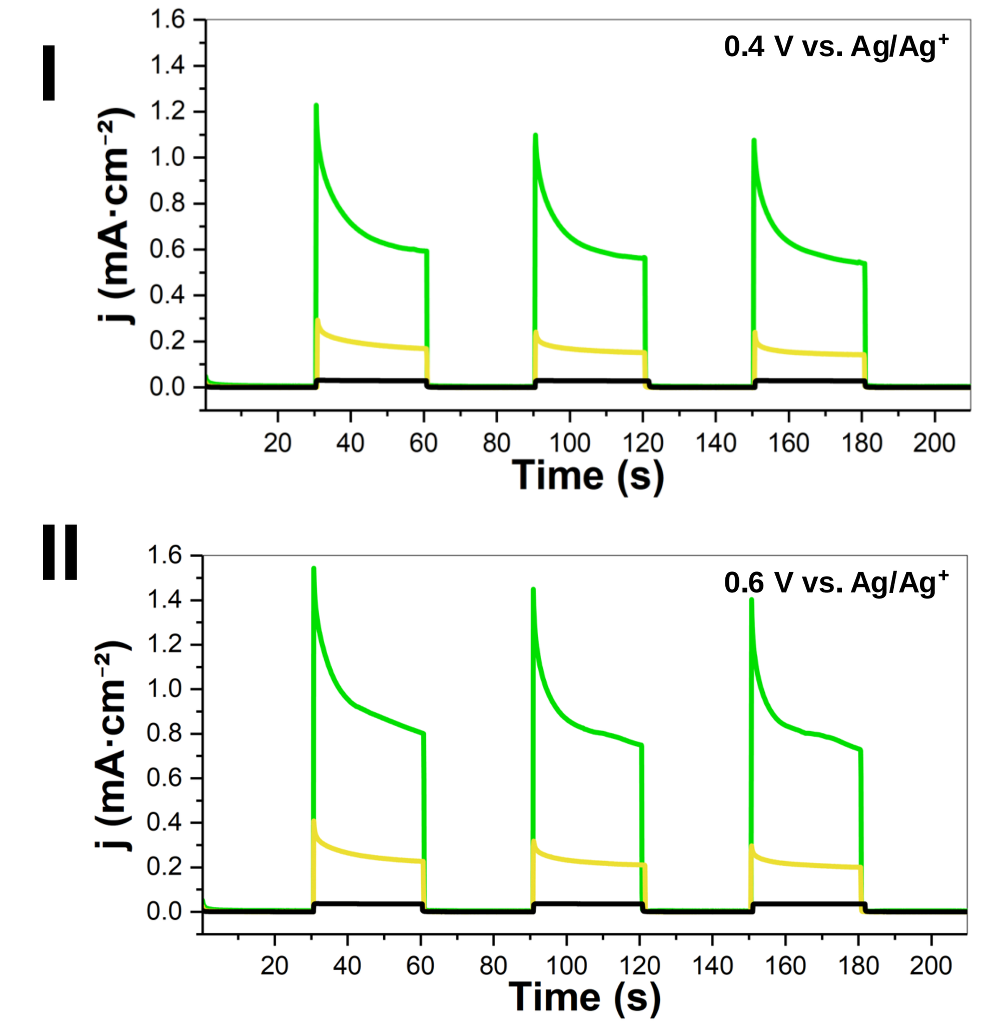


Figure 4. Transient photocurrent measurements for FTO|WO_3 (black), FTO|BiVO4 (2L) (Yellow), and FTO|WO_3–BiVO4 (green) electrodes in electrolyte with 5 mM TEMPO (I) under an applied bias of 0.4 V vs. Ag/Ag^+ and (II) under an applied bias of 0.6 V vs Ag/Ag^+ . All data were recorded in acetonitrile solution with 0.1 M $TBAPF_6$ containing 5 mM TEMPO, under aerobic conditions, with 100 mW cm^{-2} white light (1 sun) illumination.

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, with changes in absorption linked to the precursor solution and deposition method.

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.