Synthesis of Tin Oxide by Varying Electrolyte Solutions Using an Electrochemical Process

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Abstract

Tin oxide (SnO_2) is a semiconductor material with a wide bandgap of 3.6 eV. It exhibits excellent electrical, chemical, and optical properties, high transparency and corrosion resistance. Typically, tin oxide can be synthesized by various techniques, including sol-gel method, hydrothermal method, nanopowder sintering method and electrochemical method. Among these techniques, electrochemical synthesis requires less time and is simpler. In this study, Tin oxide was synthesized using a solution-based electrochemical method with varying electrolyte solutions consisting sodium citrate mixed with potassium chloride, sodium hydroxide and sodium chloride. UV-visible (UV-Vis) spectroscopy results indicate a higher bandgap than the conventional. In conclusion, this synthesis method produces tin oxide. The obtained material shows potential for applications in anti-reflective coatings, perovskite solar cells, and other electronic devices.

Objective

- To study the effect of varying electrolyte solutions on tin oxide.
- Characterization using ultraviolet-visible (UV-Vis) absorption spectroscopy and photoluminescence (PL) optical analysis techniques.

Introduction

This research focuses on the electrochemical synthesis of SnO_2 using different electrolyte solutions, including sodium citrate mixed with potassium chloride, sodium hydroxide, and sodium chloride. The synthesized materials are analyzed using ultraviolet-visible (UV-Vis) spectroscopy and photoluminescence (PL) analysis to determine their bandgap values and optical properties.

Tin oxide (SnO_2)

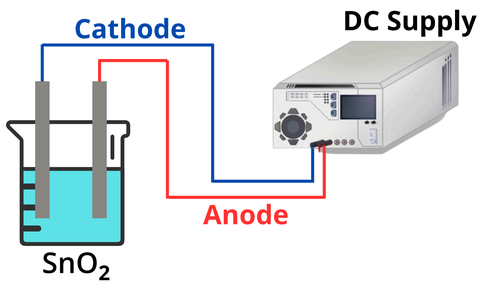
- Semiconductor material
- High transparency in the visible light range.
- Highly resistant to corrosion and chemically stable.

The substance can be applied in the production of anti-reflective coatings and perovskite solar cells.

Methodology

3 types of electrolyte solutions

- NaCT 0.02M + KCl 0.06M +DI Water 30 mL.
  - ➔ Apply a potential difference of 16 volts for 30, 45, and 60 minutes.
- NaOH 0.01M, 0.5M + DI Water 30 mL.
  - ➔ Apply a potential difference of 6 volts for 4 hours and 30 minutes.
- NaCl 0.1 - 0.5M + DI Water 30 mL.
  - ➔ Apply a potential difference of 6 volts for 1 hours and 30 minutes.



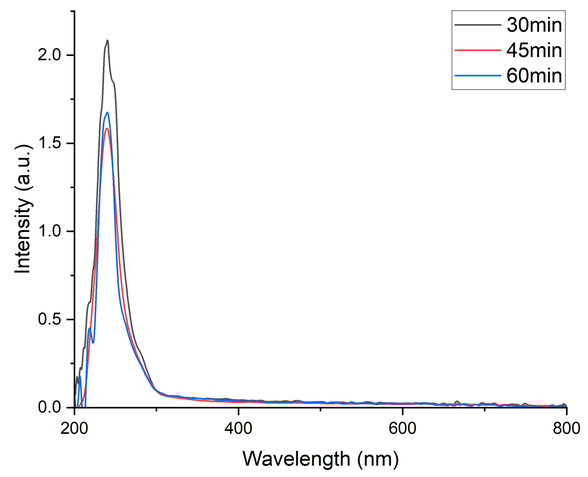
Conclusions

In the synthesis of tin oxide by the electrochemical process, the synthesized material exhibits light absorption at similar wavelengths, ranging from 200 to 300 nm. However, the electrolyte solution of NaCT 0.02M mixed with KCl 0.06M yields better results compared to other electrolyte solutions. This is evident from the band gap energy value, which is closest to the standard value of tin oxide. The obtained band gap energy indicates that the synthesized tin oxide consists of small-sized particles.

Refferences

- ARYA, Sandeep, et al. Electrochemical detection of ammonia solution using tin oxide nanoparticles synthesized via sol–gel route. Applied Physics A, 2018, 124: 1-7.
- ASAITHAMBI, S., et al. Improved photocatalytic performance of nanostructured SnO 2 via addition of alkaline earth metals (Ba 2+, Ca 2+ and Mg 2+) under visible light irradiation. Applied Physics A, 2020, 126: 1-12.

Results



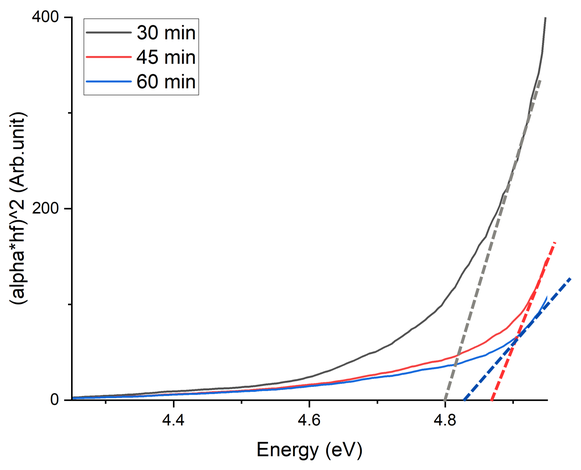


Figure 1 shows the light absorption characteristics of tin quantum dots in NaCT and KCl electrolyte solutions under the conditions of 30, 45, and 60 minutes. Figure 2 presents the relationship of the Tauc plot in the wavelength range of 200–300 nm under the conditions of 30, 45, and 60 minutes.

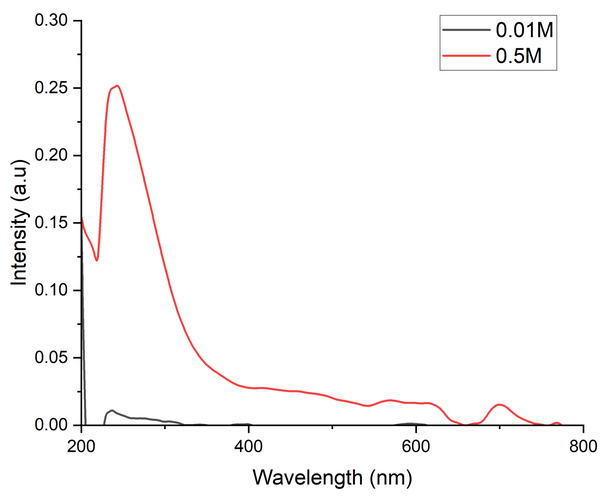
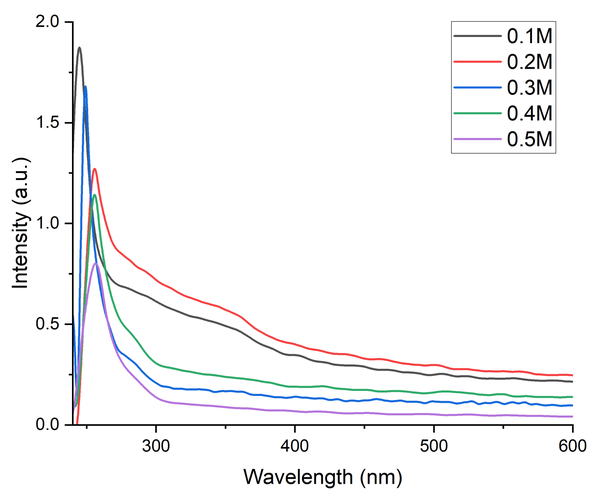


Figure 3 shows the light absorption characteristics of tin quantum dots in NaOH electrolyte solution at concentrations of 0.01M and 0.5M.



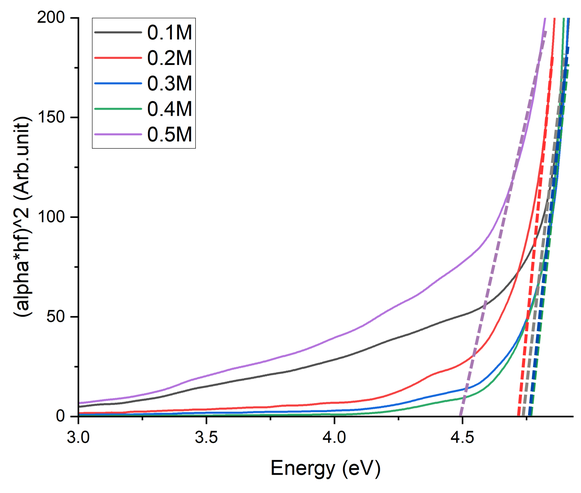


Figure 4 shows the light absorption characteristics of tin quantum dots in NaCl electrolyte solution at concentrations of 0.1, 0.2, 0.3, 0.4, and 0.5M. Figure 5 presents the relationship of the Tauc plot in the wavelength range of 225–300 nm at concentrations of 0.1, 0.2, 0.3, 0.4, and 0.5M.

Conditions		Energy band gap (eV)
NaCT + KCl	30min	4.80
	45min	4.87
	60min	4.83
NaOH	0.01M	-
	0.5M	-
NaCl	0.1M	4.94
	0.2M	4.94
	0.3M	5.10
	0.4M	5.10
	0.5M	4.50

Table 1 presents the estimated band gap values of tin quantum dots for all electrolyte solutions and all conditions.