An investigation of Transition Metal Oxides in p-Type Dye-Sensitized Solar Cells

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Introduction

In a society increasingly dependent on energy production, the need for alternative energy forms is becoming a priority. Fossil fuels and other traditional means by which the world has been supplying their energy are running out, as well as detrimentally harming the environment. Research in Solar energy has become a priority. Little is known about the use of low cost transition metal oxides, such as Vanadium Oxide, Manganese Oxide, Cobalt Oxide and Iron Oxide in p-type dye sensitized solar cells. The various oxidative states possible with these transition metal oxides makes them viable candidates in the exploration of their use in dye-sensitized solar cells, due to the oxidation reaction that may occur with the illumination of the dye sensitizer.

Hypothesis

- From previous research on NIO DSSC's:
  - Normally NiO is a light colored metal oxide
  - Due to defects from oxidation upon exposure to air, however, it has been observed that the nickel metal oxidizes from 2+ to 3+. Thus, it actually appears to be black.
  - Ni's 3+ holes are also more localized on individual Ni atoms, due to its 3d orbital structure.
- Hypothesized Reaction:
  - Localized electrons in 3D orbital (transition metal row) participate in redox reaction:
    - $M^{n+} + Dye \rightarrow M^{n+} + Dye^-$

Materials & Methods

- The most common oxidative states for the transition metal oxides of Manganese (2+3+) Oxide, Cobalt (2+3+) Oxide, and Vanadium (5+) are synthesized.
- Synthesized via a modification of a research paper that uses a sol-gel method for synthesizing NIO thin films.
  - The equivalent amount of 7.72x10^-6 moles of a soluble metal salt from each oxide will be combined with 1g of water, 3g of ethanol, and 1g of a F108 polymer.

Results

Common Oxide Results

- Each plate is taped off to form a square area in the middle of an FTO glass plate.
  - 50 micro-illiters of the metal solution are deposited on each of the glass plates (conducting side).
  - A microscope slide is used to doctor blade the film evenly, and the solution is let to dry.
  - The plates were annealed at 250°, 350° and 450°C

Monoxide Syntheses

- Cobalt Acetate, ethanol and polyethylene glycols 4000 were combined in an autoclave and put in the oven at 150°C for 24 hours.

Monoxide Results

- Under Nitrogen atmosphere, Manganese acetate and ethanol were combined and transferred to a Teflon-lined stainless steel autoclave. The autoclave was heated at 200°C for 24 hours.

Monoxide Sensitizers

- Light and Dark Comparison of Dye - Current Density vs Potential

Dye Sensitizers

- O18$^+$ 0.138V
- O18$^-$ 0.106V

Conclusions

- Optimize uniformity of films
- Test cells using new high performing dyes
- Synthesize and Test FeO solar cells
- Tungsten Oxide Doping

References


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