2014 Energy Symposium
April 9 - 10, 2014
Poster Winners

The Center for Sustainable Energy acknowledges and appreciates funding from Phillips 66 that make it possible to grant the Center for Sustainable Energy poster awards.
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1st Place - $750.00

Steven Klankowski, Yichen Zheng and Jun Li, Department of Chemistry, Kansas State University, Manhattan, KS 66506

Motivation

The hybrid nanomaterials have the potential to transform the performance of traditional devices. A vertically aligned carbon nanotube (VACNT) array can be used as a rapid reagent, and is used as a switching circuit, instead of a switchable circuit, and can be used in the formation of active micro-nanodevices everywhere. Metal oxides, such as lithium titanium oxide (LTO) and silicon dioxide (SiO$_2$), are used in hybrid devices as a sensor and a reagent, respectively, due to their corresponding Li$_i$O$_i$ electrochemical properties. The voltage stability, energy density, and cycle life are all improved compared to the traditional use of lithium-ion batteries. In this VACNT-based design, we report new insights into the use of hybrid materials.

Experimental Design

Electrode fabrication:

- VACNTs grown on copper or stainless steel by PVA.
- Electrochemical deposition to a thickness of 3-5 μm, which can be repeated up to 15 times.
- VACNTs, Pt, and Li metal are deposited using electroplating.

- Lithium-terminated carbon nanotube (LTCNT) is used as a reference electrode.

Electrochemical characterization:

- CV, EIS, and impedance spectroscopy are used to analyze the performance of the hybrid device.

- The hybrid device is compared to traditional lithium-ion batteries.

Silicon Coated VACNT Anodes

- X-ray photoelectron spectroscopy (XPS) is used to analyze the composition of the anodes.
- The anode is coated with a thin layer of silicon to improve the performance.

Summary on Si-coated VACNT Anodes

- The Si-coated anodes show improved cycling stability and higher energy density compared to traditional anodes.

Lithiated Titanium Oxide

- LTO is used as a reference electrode.

Lithiated Cobalt Oxide

- Co$_2$O$_4$ is used as a reference electrode.
Andrew McGowan and Charles Rice, Department of Agronomy, Kansas State University, Manhattan, KS  66506
2nd Place - $500.00

Fariba Fateh\textsuperscript{1}, Warren White\textsuperscript{2}, Don Gruenbacher \textsuperscript{1} Department of Electrical and Computer Engineering, \\
\textsuperscript{2}Department of Mechanical and Nuclear Engineering, Kansas State University, Manhattan, KS  66506
2nd Place - $500.00
Joshua Toevs, Yiqun Yang, Jun Li, Department of Chemistry, Kansas State University, Manhattan, KS 66506

Synthesis of Gold Nanoparticles Toward Plasmonic Enhanced Dye Sensitized Solar Cells
Joshua Toevs, Yiqun Yang, Jun Li
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Abstract
Demonstrated solar cells (DSSCs) are a class of ambient solar cells that convert sunlight into electrical energy. Because DSSCs have been recognized as a viable approach to enhance the energy efficiency and lower the cost, Gold nanoparticles (GNPs) have been utilized. Plasmonic properties for increasing light harvesting of DSSCs. Toward this goal, it requires to synthesize large quantities of uniform, well-dispersed, and plasmonic properties matching the dye absorption wavelength. This research is focused on using the high-aspect-ratio method (HARM) followed by effective opening of proper flakes. The combined approach was able to allow the highly dispersed GNPs on the surface of the DSSCs at 400 nm. The surface plasmon resonance peak was observed at 510 nm, matching that needed to excite the N715 dye.

Motivation
Surface Plasmon resonance of GNPs that are vertically aligned provides a very strong near field that matches the dye absorption wavelength, which can excite the dye molecules, and enhances their ability to harvest light.

Methods
Three steps were involved in the synthesis of rod-like nanoparticles for DSSCs:
1. HARM method to prepare raw GNPs (this work).
2. Effective opening with that sized to sense the N715 excitation (this work).
3. Surface plasmon-enhanced GNPs

Two methods were used to improve the results of the synthesis and effective opening of gold nanoparticles (11). Uniform circularly shaped GNPs were doped with the efficient molecules, ideally the GNPs will show strong peaks around 550 nm.

Results

Experimental Design

Conclusion
New large quantity of GNPs can be prepared by the HARM method.
With the effective opening of the GNPs, the GNPs can absorb light in the visible spectrum and thus be used in DSSCs. The GNPs spectrum showed the potential for the synthesis and effective opening of large GNPs. However, only when all the GNPs were used, the GNPs showed 400 nm and 510 nm peaks, which is a decrease in energy and a non-excitation of the N715 dye. The absorption peak for 400 nm of the GNPs were 300 nm, which matches the reaction to excite the DSSCs on a N715 dye.

Future Plan

Acknowledgments

References

Figure 1: This photo shows the surface plasmon resonance of a GNPs film.

Figure 2: The synthesis involves the reduction of gold ions in the presence of a reducing agent, followed by the addition of a capping agent.

Figure 3: The photograph shows the DSSC device, where the GNPs are spread evenly on the dye layer.
Production of Lactic Acid from Biomass Derived Sugars using Co-culture Fermentation

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Motivation
- Lactic acid is one of the top biomass derived platform chemical, widely used in food, pharmaceutical and cosmetic industry (Fig. 1).
- Lactic acid can be polymerized to poly-lactic acid, which is 100% recyclable & biodegradable and has multifaceted applications.
- Lactic acid demand: over 800,000 tons by 2020 [1].
- Efficient utilization of both cellulose and hemicellulose derived sugars has the potential to reduce the production cost of lactic acid by as much as 25% [1].

Hypothesis
- Lactic acid production using co-culture method.
- Lactic acid production using strain combination.

Approach
- Fermentation:
  - pH 5.0
  - Temperature: 37°C
  - Agitation: 150 rpm
  - Simultaneous co-culture
- Co-culture (L. pentosus & L. delbrueckii)

Objective
- Complete utilization of biomass sugars using co-culture technique for lactic acid fermentation.
- Maximize lactic acid production with minimum by-product formation.

Results
- Sequenced fermentation completely removed the by-product formation.
- Increased lactic acid production efficiency.

Conclusion
- Co-culture fermentation improved the performance and productivity of lactic acid production.
- The co-culture strain was completely removed and free of by-products.

Reference
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Role of bicycle in achieving sustainable urban development

Maryam Hamekhasi and Charles Barden

Overview and Background
The term bicycle was coined in France in the 1860s. Bicycles became very popular among elites and the middle classes in Europe and North America in the middle and late 1800s. Bicycle historians often call this period the "golden age" of bicycle (Clark). Innovations, such as the steam train in 1840s, electric trains in 1870s, and steam car in 1880s, made transportation faster and more convenient. However, by the middle of the 20th century, the United States became a nation of drivers, with a single-car home being the norm.

Study's purpose and Methods
Emphasizing that bicycling should be limited to those who are highly trained, extremely fit, and able to deal with traffic on busy roads. We need to find ways to make bicycling more convenient, safe, and accessible to everyone. The study involved collecting data on bicycle usage, documentation, and the prevalence of bicycling in the United States. The main method for the study was the collection of data on bicycle usage and the prevalence of bicycling in the United States.

Results
Quantification of sustainability indicators is considered one of the key elements of sustainable development. In 2008, approximately 30% of people in the United States live in communities without a safe, reliable bicycle infrastructure. In 2001, only 15% of students were walking or bicycling to school. Bicycling now accounts for nearly 10% of all trips and 10% of all traffic. Yet, less than 2% of people in the United States currently use bicycles for transportation. In the United States, the bicycle is an effective and affordable mode of transportation.

Conclusion
In many ways, bicycling is the ideal mode of transportation for urban areas. It is sustainable, it is space efficient, it is cheaper than other modes of transportation. Bicycling is a viable mode of transportation in the United States and can contribute to sustainable urban development. The following suggestions will help increase bicycling and make it a more viable mode of transportation:

1. Implementing policies that encourage bicycling, such as creating bike lanes and designated areas for bikers.
2. Promoting bicycling through educational programs and campaigns.
3. Providing incentives for bicyclists, such as tax breaks for purchasing bicycles.
4. Building bike-friendly infrastructure, including bike paths and bike racks.

People’s Choice Awards ($300.00)
Maryam Hamekhasi¹, Charles Barden², ¹Biological and Agricultural Engineering, ²Department of Horticulture, Forestry and Recreation Resources State Extension Forester, Kansas State University, Manhattan, KS 66506
People’s Choice Awards ($300.00)

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Sorghum as an Advanced Biofuel: Price Effect on Wheat, Corn and Soybean Markets

Krishna Pokharel, Rulianda Wibowo, Frank K. Nti

Background

- The 2007 US Energy Independence and Security Act (EISA) requires the US biofuel mandate to increase to 36 billion gallons by 2022.
- The 2017 US Biofuel Mandate requires total biofuel production to increase to 36 billion gallons by 2022.
- The energy independence and security act further stipulate that more than 15% of US biofuel production in 2022 must come from sources – grain, sorghum, wheat, etc – other than corn.
- In 2012, the EPA announced that grain sorghum ethanol is qualified as renewable fuel with more carbon credit than the corn-based ethanol.
- This may result in the land use change from planting wheat and other grains to planting sorghum. However, the problem of increased sorghum production could cause a decrease in food supply leading to an upward pressure on grain prices.

Research Objectives

The specific objectives are to:
1. To quantify the sorghum and wheat grain price change and the effect of sorghum yield on wheat price change.
2. To quantify price volatility for each crop and the effect of wheat yield on sorghum price change.
3. To analyze the change in trend of crop prices and land use under sorghum and wheat.

Data

Data are for Kansas corn, sorghum, soybeans, and wheat for a 6-year time period, 1995-2013. The data includes prices, yields, and harvested acreage for corn, sorghum, soybeans, and wheat from the National Agricultural Statistics Service (NASS). Acreage data for the respective crops are in annual form. The yield and average data are in aggregates for the state and non-aggregated crop data. In addition, the forward price index is being used as an index for production expectations. The forward prices for all crops were obtained from CBOT (Commodity Research Bureau).

Selected Results

- The trend of land use for sorghum and wheat is decreasing with time.
- The price of sorghum is increasing with time.
- The price of wheat is decreasing with time.
- The price of soybeans is increasing with time.
- The price of corn is decreasing with time.

Key Findings

- The price of sorghum is positively correlated with the price of wheat.
- The price of wheat is negatively correlated with the price of soybeans.
- The price of soybeans is positively correlated with the price of corn.
- The price of corn is negatively correlated with the price of sorghum.
Computational study of the mechanism for water oxidation to molecular oxygen by cobalt oxide electrocatalyst

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Hypothesis:
- Water oxidation to molecular oxygen is a challenging reaction due to the high energy barrier and the low stability of oxygen atoms.
- Cobalt oxide has shown promise as an electrocatalyst for water oxidation due to its high activity and stability.

Methodology:
- The study involves computational simulations using density functional theory (DFT) to explore the electronic structure and reaction pathways for water oxidation on cobalt oxide.
- The simulations aim to identify the most stable intermediates and products, as well as the activation energies for each step.

Proposed Mechanism:
- The water oxidation mechanism on cobalt oxide involves the following steps:
  1. Adsorption of water on the cobalt oxide surface.
  2. Formation of a hydronium ion (H3O+) by proton transfer.
  3. Oxidation of the hydronium ion to molecular oxygen (O2).

Results:
- The computational simulations reveal a low activation energy for the water oxidation reaction on cobalt oxide, indicating that it could be a promising electrocatalyst.
- The simulations also predict the formation of molecular oxygen as the final product, consistent with experimental observations.

Conclusion:
- The computational study supports the potential of cobalt oxide as an efficient electrocatalyst for water oxidation, which is a crucial reaction in water splitting and fuel cell technologies.

Future Work:
- Further experimental validation is needed to confirm the computational predictions.
- The study could be extended to explore the effects of different cobalt oxide structures and dopants on the catalytic activity.

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