

Renewable Energy and Energy Storage Room Naupaka Salon 1-3 - Session RE-TuP

Renewable Energy and Energy Storage Poster Session

RE-TuP-1 Graphene-Based Solar Cell Energy Harvester Intermittently Recharges a Battery-Powered Temperature Sensor System, Paul Thibado, Jim Mangum, Tamzeed Amin, Syed Rahman, Rezaul Kabir, Ashad Ashaduzzaman, University of Arkansas; Gordy Carichner, Hung Do, David Blaauw, University of Michigan, Ann Arbor

Transparent, flexible, and electrically conductive graphene membranes hold great promise for multimodal energy harvesting. These sources include solar and ambient radiation, thermal, acoustic, and kinetic power. This poster reviews several graphene energy-harvesting avenues, then focuses specifically on the fabrication of graphene-based solar cells using mainstream semiconductor manufacturing methods. Our two-write maskless laser lithography process creates an array of graphene-based solar cells on a commercially available 100-mm silicon wafer topped with a 2-micron thick wet thermal oxide layer on top. The first pattern marks the wafer locations for etching the silicon dioxide down to the bare silicon substrate. The second pattern marks the wafer for gold traces and bonding pads. Once completed, the exposed silicon and graphene bonding pad are covered using a large-area graphene transfer method. The samples are then characterized using atomic force microscopy, optical microscopy, and photovoltaic measurements. We also used our energy harvester to charge a 3-volt rechargeable battery, which is simultaneously driving an ultralow power consuming custom temperature sensor system. This work was financially supported, in part, by a grant from the WoodNext Foundation, which is administered by the Greater Houston Community Foundation.

RE-TuP-2 A Study on Robust VO₂ Protection Layer and Defect Inactivation in BiVO₄ Photoelectrodes through Photoelectrochemically Transition-Metal Engineering, Hyung Koun Cho, Kun Woong Lee, School of Advanced Materials Science & Engineering, Sungkyunkwan University (SKKU), Republic of Korea

Photoelectrochemical (PEC) cells for water splitting have garnered significant attention as a promising technology for solar-to-hydrogen energy conversion. Bismuth vanadate (BiVO₄), serving as the photoanode among photoelectrodes, stands out as a representative ternary oxide-semiconductor with several advantages. However, BiVO₄ photoanodes face controversial issues such as surface defects, performance limitations, and susceptibility to photo-corrosion instability. To address these challenges, we propose a groundbreaking protection layer. Based on deep understanding of the photo-corrosion mechanism regarding the dissolution of V⁵⁺ ions on BiVO₄ surface, we introduce a surface photoelectrochemical oxidation approach. By strategically introducing V⁵⁺ ions and H₂O₂ into the electrochemical electrolyte, we artificially modify photo-corrosion into advanced photo-oxidation. This induces a surface phase transition, leading to the formation of a novel vanadium oxide (VO₂) photoelectrochemical protection layer by transitioning the V⁵⁺ ions to the electrochemically favorable V⁴⁺ state. This layer is both conductive and ultrathin (~ 5 nm), while offering atomic-level controllability.

Characterizations of the BiVO₄/VO₂ photoanodes reveal enhanced carrier dynamics, with faster transport of interfacial charges (86%) and efficient transfer of photogenerated carriers through the VO₂ protection layer (95%). This innovative approach enables near-ideal performance, contributing to high stability and remarkable durability. Consequently, the BiVO₄/VO₂/CoFeO_x photoanodes exhibit an impressive photocurrent density of 6.2 mA/cm² and an onset potential of 0.25 V_{RHE}. Additionally, they demonstrate an applied bias photon-to-current efficiency of 2.4% at 0.62 V_{RHE} and stable operation without serious performance degradation for 100 hours, showcasing vigorous active oxygen evolution.

RE-TuP-3 Lanthanum-Doped Palladium Supported Catalyst for Selective Furfural Hydrogenation at Low Temperature, Ye Eun Kim, Chang-Hoon Jeong, Dong Hwan Cheon, Man Sig Lee, Korea Institute of Industrial Technology, Republic of Korea

As a fossil fuel reserves depleted, researchers have proposed upgrading biomass-derived chemicals from inedible sources as a renewable energy alternative. Furfural, derived from lignocellulosic biomass, is a key platform chemical convertible into over 100 compounds, including bio-fuel, fuel additives, and resin precursors. Tetrahydrofurfuryl alcohol (THFAL), produced through a series of furfural hydrogenation steps, has applications in fuels, resins, pharmaceuticals, and cleaning agents. Conventional THFAL

production processes require high temperatures (above 100 °C) and high pressures (above 20 bar) using copper chromite catalysts in a two-step hydrogenation of furfural. Consequently, researchers have sought to develop highly efficient catalysts for one-pot systems under mild conditions.

Herein, we propose a palladium (Pd) supported on lanthanum-doped wrinkled silica catalyst for the selective hydrogenation of furfural to THFAL. Contrary to previous reports suggesting that the acidity promotes furfural hydrogenation, we found that the Lewis basicity plays a crucial role in THFAL yield. Lanthanum doping significantly alters the surface charge, resulting in highly dispersed Pd nanoparticles on the lanthanum-doped wrinkled silica.

This research introduces the optimal loading of lanthanum species and discusses the synergetic effects of basic sites and Pd electronic states on selective hydrogenation of furfural. Our findings provide a guide for developing catalysts for upgrading biomass-derived feedstocks, potentially advancing the field of sustainable chemical production.

RE-TuP-4 The Effect of Melamine Content on 1-Phenyl-1-Propanol Hydrogenolysis over Nitrogen Doped Pd/C, Dong Hwan Cheon, Korea Institute of Industrial Technology, Pusan National University, Republic of Korea; Ye Eun Kim, Chang-Hoon Jeong, Man Sig Lee, Korea Institute of Industrial Technology, Republic of Korea

The doping of heteroatoms alters the distribution of delocalized electrons on the carbon surface, enabling the fine-tuning of carbon material properties. This strategy involves introducing heteroatoms such as boron (B), nitrogen (N), oxygen (O), phosphorus (P), and sulfur (S) into the carbon structure. Among these heteroatoms, nitrogen (N) is particularly advantageous due to its bonding radius, which is similar to that of carbon, leading to relatively fewer structural defects compared to other elements[1]. This characteristic has spurred research into the use of nitrogen-doped carbon materials as supports of catalysts for hydrogenolysis reactions. Among the nitrogen doping methods, the post-treatment approach allows for nitrogen incorporation by calcination a carbon material mixed with a precursor containing heteroatoms. This process involves combining carbon with precursors such as dicyandiamide, urea, or melamine, with numerous studies investigating their effectiveness during calcination. Notably, melamine, an aromatic molecule rich in nitrogen atoms, enhances nitrogen doping when calcined with carbon. In this study, we investigated the influence of different melamine contents on the catalytic activity of palladium (Pd) catalysts supported on melamine-led nitrogen doped carbon (NC) for the hydrogenolysis of 1-phenyl-1-propanol. To synthesize of NC, carbon black and melamine were physically mixed in a mortar in varying ratios, and the resulting mixture was subjected to calcination in a furnace. Subsequently, a series of Pd/NC catalysts were prepared using a strong electrostatic adsorption method, allowing for the variation of melamine content in the catalysts. Comprehensive physical and chemical characterizations were conducted, including FT-IR, Raman spectroscopy, BET, XPS, XRD, and CO-chemisorption, to analysis of the Pd/NC catalysts utilized in hydrogenolysis reactions. The catalytic performance of Pd/NC catalysts with different melamine content was evaluated using 1-phenyl-1-propanol hydrogenolysis reaction. After thermal treatment with a melamine to CB mass ratio of 2:1, the application of the Pd/NC67 catalyst, which is supported with palladium (Pd), resulted in a conversion rate of 96.1% for 1-phenyl-1-propanol, 100% selectivity for propylbenzene, and a yield of 98.8%. These results demonstrate superior activity compared to the Pd/CB catalyst that underwent no nitrogen doping process. Consequently, the increase in the amount of nitrogen doped into the carbon support enhances the particle size and dispersion of Pd, suggesting that the increased dispersion and reduced particle size positively impact the catalytic performance[2].

RE-TuP-5 Improving the Performance of Co-CeO₂ Catalyst for Water Gas Shift Reaction to Hydrogen Production from Combustible Waste Through Addition of Transition Metal Oxides, Chang-Hoon Jeong, Ye Eun Kim, Dong Hwan Cheon, Man Sig Lee, Korea Institute of Industrial Technology, Republic of Korea

Recently, hydrogen has been receiving worldwide attention as an eco-friendly energy source. There are various technologies for producing hydrogen, and among them, technology for hydrogen production from combustible waste is receiving attention as interest in it is increasing. The production of hydrogen from combustible waste requires gasification and water gas shift (WGS) reaction processes. The water gas shift reaction is applied to the production of additional hydrogen from carbon monoxide in synthesis gas (CO+H₂) derived from waste. Co-based catalysts have been

Tuesday Afternoon, December 10, 2024

applied to WGS reactions because they have a significant capacity and high reaction rate for CO oxidation. Co-based catalysts showed high activity for the WGS reaction, but it was necessary to enhance the stability. Here, different transition metal oxides (TiO_2 , ZrO_2 , V_2O_5 , and Nb_2O_5) are used as promoters to enhance the Co– CeO_2 catalyst performance. To investigate the effects of promoters on the catalytic performance, various catalyst properties are characterized. Physicochemical properties, which are related to the catalytic performance, are influenced by promoters. The addition of promoters affects the surface area, Co dispersion, oxygen vacancies, and interactions between Co and the support. Among the synthesized catalysts, the Co– Nb_2O_5 – CeO_2 catalyst exhibits the highest performance at a substantially high gas hourly space velocity owing to its high Co dispersion, numerous oxygen vacancies, and strong interactions between Co and the support. These findings are expected to aid the development of high-performance CeO_2 -based catalysts.

Author Index

Bold page numbers indicate presenter

— A —

Amin, Tamzeed: RE-TuP-1, **1**
Ashaduzzaman, Ashad: RE-TuP-1, **1**

— B —

Blaauw, David: RE-TuP-1, **1**

— C —

Carichner, Gordy: RE-TuP-1, **1**
Cheon, Dong Hwan: RE-TuP-3, **1**; RE-TuP-4, **1**;
RE-TuP-5, **1**
Cho, Hyung Koun: RE-TuP-2, **1**

— D —

Do, Hung: RE-TuP-1, **1**

— J —

Jeong, Chang-Hoon: RE-TuP-3, **1**; RE-TuP-4, **1**;
RE-TuP-5, **1**

— K —

Kabir, Rezaul: RE-TuP-1, **1**
Kim, Ye Eun: RE-TuP-3, **1**; RE-TuP-4, **1**; RE-
TuP-5, **1**

— L —

Lee, Kun Woong: RE-TuP-2, **1**
Lee, Man Sig: RE-TuP-3, **1**; RE-TuP-4, **1**; RE-
TuP-5, **1**

— M —

Mangum, Jim: RE-TuP-1, **1**

— R —

Rahman, Syed: RE-TuP-1, **1**
— T —
Thibado, Paul: RE-TuP-1, **1**