



**C-Zerōization** | Fostering Human  
Recourses for C-Zeroization  
in Asia countries Project



**Book of Abstract**

# The 4<sup>th</sup> Symposium on Socio-technical Innovation for Zero Carbon in Asian Countries

Nagoya University, Japan  
18-19<sup>th</sup> January 2024



## Welcome Message from Dean, Fostering Human Resources for C-zeroization in Asia Countries, Nagoya University



On behalf of the Organizing Committee, I am honored and delighted to welcome you to this 4<sup>th</sup> *Socio-technical Innovation for Zero Carbon in Asian Countries*. The workshop is based on the Fostering Human Resources for C-Zeroization in Asian Countries Project. We are proud to announce that this international workshop is being conducted along with the cooperation of Nagoya University together with consistently step forward in the development of human resources to drive C-Zeroization Shanghai Jiao Tong University, Korea Maritime & Ocean University, and Chulalongkorn University, and is intended to be the SDGs achievement from a glocal (global-local) perspective toward a sustainable society in Asia.

We believe this workshop will give opportunities for sharing and exchanging original research knowledge and vast opinions, gaining inspiration for solving the problem of CO<sub>2</sub> emissions, and developing human behavior to drive C- Zeroization in Asian countries.

The workshop focuses on the thematic areas of Biomaterials, Bioplastic and Green Plastic, Renewable Energy, Energy Generation & Storage for CO<sub>2</sub> Zeroization, Advanced & Functional Materials, Green technologies, Capture emissions technology, and Social & Solidarity Economy and Social Development, along with 2 sections of presentations, including a lecture from a specialist professor and presentation from students, thus focusing attention on the contemporary outstanding achievements in the field of C-Zeroization and subsequent development and demands.

We would like to thank all the eminent speakers and guests from different countries who have come here and submitted their excellent works to this workshop. Lastly, we are eternally grateful to the Ministry of Education, Culture, Sports, Science and Technology (MEXT), Japan, for supporting the 4<sup>th</sup> *Socio-technical Innovation for Zero Carbon in Asian Countries Workshop at Nagoya University, Nagoya, Japan*.

Sincerely Yours,

A handwritten signature in black ink that reads "Nagahiro Saito".

Nagahiro Saito, Professor  
Dean, Fostering Human Resources for  
C-zeroization in Asia Countries Project,  
Nagoya University

# The Symposium of Fostering Human Recourses for C-Zeroization in Asia Countries Project (C-Zero)

**Topic:** The 4<sup>th</sup> Symposium on *Socio-technical Innovation for Zero Carbon in Asian Countries*

*co-organized by Nagoya University (NU, Japan), Chulalongkorn University (CU, Thailand), Korea Maritime and Ocean University (KMOU, South Korea) and Shanghai Jiao Tong University (SJTU, China)*

**Venue:** Idea Stoa, Nagoya University, Nagoya, Japan

**Online via Zoom:**

トピック: The 4th CA symposium

時刻: 2024年1月18日 09:00 AM 大阪、札幌、東京

参加 Zoom ミーティング

<https://us06web.zoom.us/j/84416978857?pwd=QX7fCnzkhvIb6HT5Caih0QXT6izuv7.1#success>

ID: 844 1697 8857

Password: 915259

**Period:** 18-19<sup>th</sup> January 2024

**Time:** Thailand 9:00, China 10:00, Japan/Korea 11:00

**Date:** Thursday 18<sup>th</sup> January 2024

Time (Japan)	Time (Japan)
11:00 – 11:20	Registration (Onsite)
<b>MC: Dr. Garbis Atam Akceoglu Asst. Prof. Chayanaphat Chokradjaroen</b>	
11:20 – 11:30	<b>Opening Remarks</b> <ul style="list-style-type: none"> <li>• <b>Prof. Nagahiro Saito</b> (Dean, Fostering Human Resources for C-zeroization in Asia Countries, NU)</li> </ul> <b>Photo Session</b>
11:30 – 11:45	<b>KMOU Prof, CU Prof, SJTU Prof</b>
11:45 – 11:50	<b>Mr. Yamanaka Koki</b> ( <i>Short-term program</i> )
11:50 – 11:55	<b>Mr. Yun Hojung</b> ( <i>Long-term program</i> )
11:50 – 12:00	<b>Presentation of KMOU</b>
12:00 – 13:00	--- <b>Lunch Break</b> --- (60 min)
<b>Chairperson 1: Prof. Takeshi Hagio (NU)</b>	
13:00 – 13:25	<b>O-001 Dr. Niu Jiangqi (NU)</b> <i>Binary Platinum-Based Nano Particles for Oxygen Reduction Electrocatalysts</i>

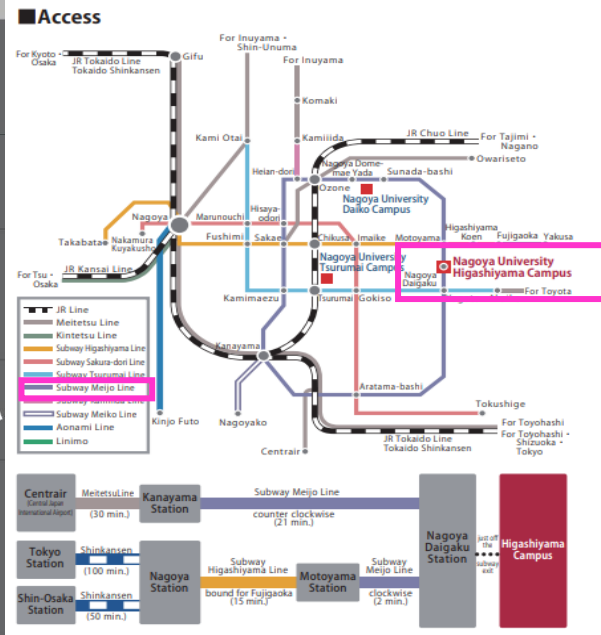
13:25 – 13:50	<b>O-002 Prof. Xufang Qian (SJTU)</b> <i>CD-COOFe<sup>III</sup> Fenton-like Catalytic Activation of H<sub>2</sub>O<sub>2</sub></i>
13:50 – 14:05	<b>O-003 Ms. Tattanon Thamonwan</b> <i>Nanostructured PtPdCu Electrocatalysts Synthesized by Solution Plasma for Oxygen Reduction Reaction</i>
14:05 – 14:20	<b>O-004 Prof. Long Kong (SJTU)</b> <i>Synthesis of ultra-stable core/shell quantum dots and its photocatalytic application</i>
14:20 – 14:45	<b>O-005 Prof. Seunghyo Lee (KMOU)</b> <i>Remediation of Water Contaminated with Diverse Pollutants by Advanced plasma technology</i>
14:45 – 14:55	--- Coffee break --- (10 min)
<b>Chairperson 2: Prof. Seunghyo Lee (KMOU)</b>	
14:55 – 15:20	<b>O-006 Prof. Sirilux Poompradub (CU)</b> <i>Alternative Materials for CO<sub>2</sub> Capture</i>
15:20 – 15:35	<b>O-007 Prof. Kanoktip Boonkerd (CU)</b> <i>Novel water-swelling natural rubber hybrid composite with sodium polyacrylate and sodium bentonite clay</i>
15:35 – 15:50	<b>O-008 Ms. Jiwoon Byeon (KMOU)</b> <i>Effects of Austenitization Temperature on High Corrosion Resistance of Hot-dip Al-Si-Sr Coated Hot Press Forming (HPF) Steel</i>
15:50 – 16:00	--- Coffee break --- (10 min)
16:00 – 17:00	<b>Poster</b> <b>P-001 Mr./Ms. Chansinee Buaphet (CU)</b> <i>Development of Wasted Eggshell-Supported ZnO Photocatalyst from Spent Alkaline Battery Electrode with Enhanced Photocatalytic Activity</i> <b>P-002 Mr./Ms. Chanittha Panyachotipun (CU)</b> <i>Platinum Nanoparticles on Polybenzoxazine-Based Porous Carbon Support for Fuel Cell Application</i> <b>P-003 Mr./Ms. Kamonpan Manowilaikun (CU)</b> <i>Synthesis of MnO<sub>2</sub> from Spent Alkaline Batteries for Zinc-Ion battery</i> <b>P-004 Mr./Ms. Wongvitvichot Wasupon (CU)</b> <i>Fast Multi-Functional Group Fluorescent Carbon Dots Synthesized from Glucosamine by In-Liquid Solution Plasma Process</i> <b>P-005 Mr./Ms. Yun Hojung (NU)</b> <i>Recycled graphite from spent Zn-C batteries for Li-ion batteries</i> <b>P-006 Mr./Ms. Naken Saetang (CU)</b> <i>Investigation on Possibility to Anticipate Corrosion Behavior of Pipelines in Supercritical CO<sub>2</sub> with Water as Impurity Using Moderate Carbonate Solutions</i> <b>P-007 Mr./Ms. Yusuke Yamanaka (NU)</b> <i>Phosphorus Recovery Using Magnetic Mg-Fe Layered Double Hydroxide</i>
17:30 – 19:30	<b>Welcome Dinner (for all professors &amp; staff)</b>

<b>Time (Japan)</b>	<b>Program</b>
<b>Chairperson 4: Dr. Niu Jiangqi (NU)</b>	
11:00 – 11:25	<b>O-009 Prof. Takeshi Hagio (NU)</b> <i>Development of Hexagonal Tungsten Oxide Membranes for Energy Saving Separation Processes</i>
11:25 – 11:50	<b>O-010 Prof. Nathaphon Raengthon (CU)</b> <i>High – Entropy Titanate-Based Perovskite Oxides for High-Performance Ceramic Capacitors</i>
11:50 – 12:05	<b>O-011 Mr. Uijun Kim (KMOU)</b> <i>Optimized synergistic effects of NiCu catalyst for ammonia oxidation reaction</i>
<b>12:05 – 13:00</b>	<b>--- Coffee break --- (55 min)</b>
<b>Chairperson 6: Prof. Sirilux Poompradub (CU)</b>	
13:00 – 13:25	<b>O-012 Mr. Seon-Jae Baek (KMOU)</b> <i>A Study on Magnetic Dual Z-Scheme Heterojunction as an Efficient Visible-Light-Driven System for Pollutant Degradation : Liquid Phase Plasma Synthesis</i>
13:25 – 13:50	<b>O-013 Mr. Ke Yifu (NU)</b> <i>Nano-Sized Cu<sub>x</sub>Ni<sub>y</sub> based alloy via Solution Plasma Sputtering for Fuel Cell Catalysis</i>
13:50 – 14:05	<b>O-014 Mr. Sato Keisuke (NU)</b> <i>Synthesis of Molybdenum Disulfide Thin Films by Combination of Spin Coating Method and Heat Treatment</i>
<b>14:05 – 14:10</b>	<b>--- Coffee Break --- (15 min)</b>
<b>Chairperson 7: Prof. Kanoktip Boonkerd (CU)</b>	
14:10 – 14:35	<b>O-015 Prof. Nisanart Traiphol (CU)</b> <i>Polydiacetylene-based Nanocomposites for Colorimetric Detection of Acid-Base in Food Products</i>
14:35 – 15:00	<b>O-016 Mr. Ziwei Liu (NU)</b> <i>Solution Plasma synthesis of Pt-Y Alloy Nanoparticle its Catalytic Property for Oxygen Reduction Reaction</i>
15:00 – 16:00	<b>Poster</b> <b>P-008 Mr./Ms. Ismaila Ibrahim (CU)</b> <i>Preliminary investigation of fructose dehydration to 5-hydroxymethylfurfural using Amberlyst-15, H-ZSM-5, H-USY and H-β Zeolite in biphasic medium</i>  <b>P-009 Mr./Ms. Hirofumi Amada (NU)</b> <i>Isolation of intermediates and investigation of reaction mechanism in the synthesis of evaporate fullerene derivatives</i>

	<p><b>P-010 Mr./Ms. Xin Li (SJTU)</b> <i>Ti-Fe<sub>2</sub>O<sub>3</sub>/Ni(OH)<sub>x</sub> as an efficient and durable photoanode for the photoelectrochemical catalysis of PET plastic to formic acid</i></p> <p><b>P-011 Mr./Ms. Yan Fang (SJTU)</b> <i>Electrocatalytic CO<sub>2</sub> Reduction Coupled with Poly (ethylene terephthalate) Plastic Valorization for Simultaneous Production of Formate</i></p> <p><b>P-012 Mr./Ms. Changhyeon Park (KMOU)</b> <i>Heteroatom-doped MoC/C Nanocomposite Synthesized by Liquid Phase Plasma for Electrochemical Ammonia Production</i></p> <p><b>P-013 Mr./Ms. Ji-Yeon Kim (KMOU)</b> <i>High Efficient Decomplexation of Cu-EDTA and Subsequent Cu Removal by Liquid Phase Plasma</i></p> <p><b>P-014 Mr./Ms. Se-Rim Kim (KMOU)</b> <i>Evaluation of Stress Corrosion Cracking Behaviors for Cu Alloy in Diverse Environments</i></p> <p><b>P-015 Mr./Ms. Sohui Kim (KMOU)</b> <i>Characterization of the Corrosion Behavior on Nitrogen-Containing Austenitic Stainless Steel: Performance of Repassivation</i></p>
<b>MC:</b>	
16:00 – 17:00	<p><b>Closing Remark – Hybrid</b></p> <ul style="list-style-type: none"> <li>• Prof. Nagahiro Saito (NU)</li> </ul> <p><b>Photo Session</b></p>

# Nagoya University (Higashiyama Campus)

**Take exit 3** from Nagoya Daigaku Station (Meijo Line) to Nagoya University Idea Stoa (NIC) **then walk 280m for 4min**



**C2 6 Building NIC Idea Stoa**

**ES building  
2008 Noble Prize Exhibition Hall**

**NIC Building**



**ES Building**



**Idea Stoa (NIC building)  
The 4th Symposium on Socio-technical  
Innovation for Zero Carbon in Asian  
Countries**



# Oral Presentation Abstract

**18 January 2024**



## Binary Platinum-Based Nanoparticles for Oxygen Reduction Electrocatalysts

Jiangqi Niu <sup>a</sup>, Chayanaphat Chokradjaroen <sup>a</sup>, Thamonwan Tattanon <sup>a</sup>,  
Pavillon Chanda <sup>a</sup>, Yuanyuan Liu <sup>a</sup>, Pengfei Wang <sup>a</sup>, Zhuoya Deng <sup>a</sup>, Yifu Ke <sup>a</sup>,  
Ziwei Liu <sup>a</sup>, Yasuyuki Sawada <sup>a</sup>, Nagahiro Saito <sup>a, b, c, d, \*</sup>

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Carbon-supported monometallic, binary nanocatalysts based on Pt-M (M = Ag, Zr, Hf, Sn, Mo, V, Y), were synthesized by solution plasma process and characterized by X-ray diffraction, thermogravimetry, transmission electron microscopy, X-ray photoelectron spectroscopy, and cyclic voltammograms. A comparative study of the oxygen reduction reaction (ORR) on monometallic, alloyed binary nanocatalysts has been performed. The catalytic activity and the selectivity of the nanocatalysts towards the ORR show that the addition of Y to Pt led to a constant increase of the activity with the degree of deoxidation of Y. Further increase in the utilization rate of Pt, the AuCu@Pt\_monolayer catalyst was synthesized. This catalyst showed improved catalytic activities towards ORR.

**Keywords:** Pt@graphene, core-shell, oxygen reduction reaction

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## CD-COOFe<sup>III</sup> Fenton-like Catalytic Activation of H<sub>2</sub>O<sub>2</sub>

Xufang Qian <sup>a, \*</sup>

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The global wastewater discharge is approximately 71 billion tons annually, an annual increase of 2 billion tons. Fenton oxidation was one of the available advanced oxidation processes in water treatment, and Fenton chemistry was also widely studied in the field of cell apoptosis, geochemistry, tumor therapeutics etc. Fenton oxidation utilizing hydrogen peroxide (H<sub>2</sub>O<sub>2</sub>) and ferrous/ferric [Fe(II)/Fe(III)] ions under acidic conditions is effective in reducing the concentrations of targeted environmental contaminants to acceptable levels. Herein, we report the homogeneous carbon dot-anchored Fe(III) catalysts (CD-COOFe<sup>III</sup>) wherein CD-COOFe<sup>III</sup> active center activates H<sub>2</sub>O<sub>2</sub> to produce hydroxyl radicals (•OH) reaching 105 times larger than that of the Fe<sup>3+</sup>/H<sub>2</sub>O<sub>2</sub> system. The key is the •OH flux produced from the O–O bond reductive cleavage boosting by the high electron-transfer rate constants of CD defects and its self-regulated proton-transfer behavior probed by operando ATR-FTIR spectroscopy in D<sub>2</sub>O and kinetic isotope effects, respectively. Organic molecules interact with CD-COOFe<sup>III</sup> via hydrogen bonds, promoting the electron-transfer rate constants during the redox reaction of CD defects. The antibiotics removal efficiency in the CD-COOFe<sup>III</sup>/H<sub>2</sub>O<sub>2</sub> system is at least 51 times larger than the Fe<sup>3+</sup>/H<sub>2</sub>O<sub>2</sub> system under equivalent conditions. Our findings provide a new pathway for traditional Fenton chemistry. This new strategy enhanced the kinetic of ferric ion reduction and broadened the pH values of the reaction.

**Keywords:** water treatment; H<sub>2</sub>O<sub>2</sub>; Fenton-like catalysis; carbon dot-anchored Fe(III) catalysts

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## **Pt@Graphene Core-shell Catalyst for Oxygen Reduction Reaction**

**Thamonwan Tattanon**<sup>a</sup>, Jiangqi Niu<sup>a</sup>, Chayanaphat Chokradjaroen<sup>a</sup>, kyunung kim<sup>a</sup>,  
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Proton-exchange membrane fuel cells (PEFCs) are attracting attention as clean energy conversion devices because they generate water through the oxygen reduction reaction (ORR) between hydrogen and atmospheric oxygen, and efficiently extract the energy generated by the chemical reaction directly into electricity. Platinum (Pt) catalysts are used at the anode and cathode of PEFCs to facilitate the chemical reaction. However, utilizing only Pt particles may lead to uneven durability of the catalyst, potentially affecting the overall reaction. In this study, Pt@graphene core-shell catalyst was synthesized by solution plasma and followed by the post-treatment which is plasma etching, to enhance reaction reactivity and durability. The solution plasma process resulted in multi-layers of graphene which coated on the surface of Pt, potentially hindering the oxygen reduction reaction. Consequently, plasma etching was employed to precisely control the graphene layers to ensure a more effective chemical reaction. This research aims to contribute to the advancement of PEFCs technology by addressing and optimizing the key factors influencing catalyst reactivity and durability.

**Keywords:** Pt@graphene, core-shell, oxygen reduction reaction

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**Synthesis of ultra-stable core/shell quantum dots and its photocatalytic application****Long Kong<sup>a\*</sup>, Cong Zou<sup>a</sup>, Lu Huang<sup>b</sup>, Liang Li<sup>c\*</sup>**<sup>a</sup> School of Environmental Science and Engineering, Shanghai Jiao Tong University, Shanghai, 800 Dongchuan Road, 200240, China<sup>b</sup> School of Agriculture and Biology, Shanghai Jiao Tong University, Shanghai, 800 Dongchuan Road, 200240, China<sup>c</sup> Macao Institute of Materials Science and Engineering, Macau University of Science and Technology, Taipa, Macao 999078, China

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Semiconductor quantum dots (QDs) have attracted extensive attention in various applications because of their unique optical and electronic properties. However, QDs suffer from poor chemical/photo-stability, which hinders their actual application. Here, we present a simple approach to enhance the photostability of QDs by metal doping into the core/shell QDs. The as-prepared CuInS<sub>2</sub>/ZnS QDs exhibited excellent photostabilities. The doped metal ions in the shell can be oxidized to metal oxides, which can serve as a self-passivation layer on the surface of QDs and thus effectively prevent photodegradation during long-term light irradiation. In addition, we successfully combined our stable QDs with TiO<sub>2</sub> to fabricate the photocatalyst. The optimum photocatalytic activity of photocatalysts can be obtained by controlling the shell thickness with the coating time of ZnS and the doping ratio in the synthesis of CuInS<sub>2</sub>/ZnS QDs. The photocatalytic substantially realized the conversion of carbon oxides to methane under sunlight. The recycling experiments indicated that the QDs-based photocatalyst was stable and reusable.

**Keywords:** quantum dots, photocatalyst, stability

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## Remediation of Water Contaminated with Diverse Pollutants by Advanced plasma technology

Seunghyo Lee <sup>a\*</sup>, Uijun Kim <sup>a</sup>, Sunjae Baek <sup>a</sup>, Jiyeon Kim <sup>a</sup>, Myeonghoon Lee <sup>b</sup>

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A novel green process, liquid phase plasma (LPP), has been developed for versatile applications, including water treatment and synthesis of catalysts. LPP offers advantages such as a short treatment time, simple setup, and direct discharge in water without chemical reagents. Previous studies demonstrated its efficacy in reducing organic and inorganic contaminants significantly. Currently, we are trying to degrade heavy metals, which are prone to cause serious environmental threats and be bioaccumulated using LPP. The results show about 90% of Cu-EDTA degradation efficiency in 10 min.

The LPP mechanism involves non-thermal plasma generation through ionization, excitation, dissociation, attachment, and detachment when a bipolar pulse power supply reaches the breakdown point. The hydroxyl radical ( $\bullet\text{OH}$ ), a potent oxidizer, plays a crucial role in the oxidation of various pollutants due to its non-selective reactivity.

ESR and OES analysis were employed to identify radicals present in the LPP reaction system. Although direct detection of radicals is challenging, spin-trapping agents revealed the presence of  $\bullet\text{OH}$  and  $^1\text{O}_2$  under LPPT conditions.

This work suggests the potential of LPP for remediating water contaminated with diverse pollutants, offering insights into the generated active species and proposing possible degradation pathways.

**Keywords:** Liquid Phase Plasma, Organic Pollutants, Inorganic Pollutants, Heavy Metals

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## Alternative Materials for CO<sub>2</sub> Capture

Krittaya Panploo<sup>a</sup>, Benjapon Chalermssinsuwan<sup>a</sup>, **Sirilux Poompradub**<sup>a, b, \*</sup>

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Natural rubber (NR) was developed as the alternative material to be used as the carbon dioxide (CO<sub>2</sub>) adsorbent. It was designed as NR foam with high porosity. In order to increase the CO<sub>2</sub> adsorption capacity, NR was filled with amine-modified silica particles. The modified silica particles were prepared by using the sol-gel process of tetraethoxysilane (TEOS) as a precursor. The effect of modified silica particles on the CO<sub>2</sub> adsorption capacity of NR composites was investigated under ambient temperature and atmospheric pressure, and the results obtained were compared with the unmodified silica particles filled NR and neat NR. The regeneration of NR composites was also studied by a combination of vacuum and temperature swing adsorption (VTSA). This research can benefit from developing a high-performance solid sorbent to play a role in solving the CO<sub>2</sub> capture problem.

**Keywords:** Rubber; CO<sub>2</sub> adsorption; Modified silica

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**Novel water-swellaable natural rubber hybrid composite with sodium polyacrylate and sodium bentonite clay**Janyarak Trakuldee<sup>a,b</sup>, **Kanoktip Boonkerd<sup>b,c\*</sup>**, and Apinya Krainoi<sup>c</sup><sup>a</sup>Multidisciplinary Program in Petro Chemistry & Polymer Science, Faculty of Science, Chulalongkorn University, Thailand<sup>b</sup>Center of Excellence in Green Materials for Industrial Application, Chulalongkorn University, Thailand<sup>c</sup>Department of Materials Science, Faculty of Science, Chulalongkorn University, Thailand

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Water swellaable rubber (WSR) is a functional polymer that expands its volume up to 1.5 times its original size by absorbing surrounding water. It has been widely used as sealants and caulks, water-blocking materials in automotive and construction industries, oil and gas fields, etc. The effective WSR can be obtained by using hydrophilic synthetic rubber such as chloroprene. However, for cost-cutting and environmental purposes, several works have replaced hydrophilic rubber with natural rubber. For all that, natural rubber is intrinsically hydrophobic, thus having extremely low water absorption. Basically, to improve the water absorbability of natural rubber, an absorbent filler is needed. Nevertheless, the dispersion of hydrophilic particles in the hydrophobic NR affected the poor interaction between them, which led to the migration of hydrophilic particles to the water phase. Therefore, we proposed an effective method to prepare a water-swellaable natural rubber composite in the present work.

**Keywords:** Water-swellaable rubber, Super absorbent polymer, Silica, Mechanical properties

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## Effects of Austenitization Temperature on High Corrosion Resistance of Hot-dip Al-Si-Sr Coated Hot Press Forming (HPF) Steel

Jiwoo Byeon <sup>a</sup>, Dongwook Seo <sup>a</sup>, Sangheon Kim <sup>b</sup>, Taeyeop Kim <sup>b</sup>, Myeonghun Lee <sup>c</sup>,  
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Hot press forming (HPF) is a thermodynamic process in which the material is heated to the austenitization temperature and then transferred from a furnace to a press tool, thereby improving tensile strength and reducing deformation. In contrast, high-temperature oxidation occurs during heat treatment in the HPF process, which is exposed to the risk of oxidation. To prevent this, Al-10Si Type 1 hot-dip aluminizing is a process widely used, which shows stability at high temperatures and excellent corrosion resistance.

On the other hand, it has been reported that Sr has the effect of refining the Si eutectic region in Al-Si alloys and can even improve weldability. Therefore, the influence of the addition of Sr as a minor alloying element was examined.

In addition, there are other reports that hot stamping of Al-Si-coated 22MnB5 steel results in significant changes in the coating layer. The morphology is changed due to iron diffusion from the steel substrate towards the coating layer. The transformation of these compounds has a direct relationship with the hot-dip parameters, such as soaking time and temperature during the austenitization step on hot stamping. Therefore, this study investigates the effect of austenitization temperature on the corrosion resistance of Al-Si-Sr hot-dip coating.

**Keywords:** Hot press forming (HPF), Sr additions, Cooling rate, Corrosion resistance



# Poster Presentation Abstract

**18 January 2024**

## Development of Wasted Eggshell-Supported ZnO Photocatalyst from Spent Alkaline Battery Electrode with Enhanced Photocatalytic Activities

Chansinee Buaphet<sup>a</sup>, Noppakhate Jiraborvornpongsa<sup>b, c</sup>, Wuttichai Reainthippayasakul<sup>a, c</sup>, and Rojana Pornprasertsuk<sup>a, d, e, f</sup>

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The aim of this research work was to transform waste into a useful and environmentally-friendly product. The anode of the alkaline battery is composed of a mixture of zinc oxide, binder, and electrolyte, which could be used as the raw materials for ZnO photocatalyst synthesis. At the same time, waste eggshells are a typical example of biological calcium carbonate (bio-CaCO<sub>3</sub>), with a porous structure useful in adsorption capability. The ZnO/CaCO<sub>3</sub> composite was prepared through combined calcination, referred to as CZC-10 to CZC-40, by weight ratio of CaCO<sub>3</sub>, respectively. The phase and microstructure were subsequently analyzed by X-ray diffraction (XRD) and scanning electron microscopy (SEM). The preliminary results revealed that all the diffraction peaks of the sample were assigned as ZnO wurtzite phase and CaCO<sub>3</sub> calcite phase without any other impurity phases. The photocatalytic activities of the obtained ZnO/CaCO<sub>3</sub> composite were investigated via the degradation of methylene blue dye under UV radiation for 240 min. The ZnO/CaCO<sub>3</sub> demonstrated 97% efficiency in methylene blue (MB) removal through photocatalytic activity. Radical trapping identified holes (h<sup>+</sup>), hydroxyl radicals (•OH), and carbonate radicals (•CO<sub>3</sub><sup>-</sup>) as crucial species. Waste eggshells enhanced activity by adsorption and acted as a resource for active carbonate radicals.

**Keywords:** ZnO; Spent Alkaline Battery; Eggshell; Photocatalysis

## Platinum Nanoparticles on Polybenzoxazine-Based Porous Carbon Support for Fuel Cell Application

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Fossil fuels significantly contribute to global pollution. To overcome this issue, many studies on proton exchange membrane fuel cells (PEMFCs), have been reported due to their efficient conversion of the electrochemical reaction between hydrogen and oxygen gases with platinum catalyst into electricity. Consequently, carbon-supported platinum has received much attention as an effective catalyst in this application because of its high thermal and chemical stability as well as high catalytic activity toward oxygen reduction reaction (ORR) at low temperatures. Many studies show that heteroatoms (N, O, B, and S) inside the carbon frameworks play a crucial role in improving the adsorption of oxygen gas during the reaction. In this study, carbon derived from polybenzoxazines (PBZs), enriched with nitrogen and oxygen, was used as the support to deposit platinum nanoparticles via the solution plasma (SP) method—an approach known for its operability under room temperature and atmospheric pressure. The electrochemical performances of the as-prepared samples were evaluated in 0.5 M H<sub>2</sub>SO<sub>4</sub>, revealing their promising potential compared to the commercially available platinum catalyst on carbon support (20 wt.% Pt/C).

**Keywords:** Fuel cell, Oxygen reduction reaction, Platinum, Carbon, Polybenzoxazine, Solution plasma

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## Synthesis of MnO<sub>2</sub> from Spent Alkaline Batteries for Zinc-Ion battery

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This study aims to recover manganese from spent alkaline batteries into manganese dioxide, which is utilized as a cathode for secondary zinc-ion batteries (ZIBs). The highest 93% yield of Mn was successfully leached from spent Zn<sub>x</sub>Mn<sub>3-x</sub>O<sub>4</sub> by using 0.5 M sulfuric acid and 0.6 M hydrogen peroxide at the leaching time of 60 min. Subsequently, the precursor leaching solution of Mn was turned into MnO<sub>2</sub> at various phases according to the hydrothermal condition. Evidently from XRD and SEM results demonstrated that the synthesized α-MnO<sub>2</sub>, β-MnO<sub>2</sub>, γ-MnO<sub>2</sub> and δ-MnO<sub>2</sub> phases were confirmed along with nanofiber, nanorod, nanourchin and nanoflower structures, respectively. All synthesized MnO<sub>2</sub> powders mainly consisted of Mn and O without Zn, suggesting the high purity of MnO<sub>2</sub>. Besides, CR2025 ZIBs were fabricated using the synthesized α-MnO<sub>2</sub>, β-MnO<sub>2</sub>, γ-MnO<sub>2</sub> and δ-MnO<sub>2</sub> as the active cathode materials and compared to those synthesized from the commercial MnSO<sub>4</sub> precursor. Surprisingly, all CR2032 ZIBs using recycled MnO<sub>2</sub> cathodes revealed the equivalent performance to those synthesized from commercial MnSO<sub>4</sub>, confirming the effective approach to using recycled Zn<sub>x</sub>Mn<sub>3-x</sub>O<sub>4</sub> from spent alkaline batteries as cathode for secondary ZIBs.

**Keywords:** Hydrothermal, Zn ion battery, MnO<sub>2</sub>

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## **Fast Multi-Functional Group Fluorescent Carbon Dots Synthesized from Glucosamine by In-Liquid Solution Plasma Process**

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Carbon dots (CDs) find diverse applications in disease diagnosis, drug delivery, photocatalysis, and solar cells, hinging on their multi-functional groups and physiological behaviors. Consequently, developing CDs with specific functional groups is crucial to their multifunctionality. Glucosamine, derived from food waste and a constituent of chitosan, contains an amine group capable of introducing N-heteroatoms to the structure. This characteristic makes it a potential enhancer for photocatalytic applications, particularly when incorporated into a conventional photocatalyst like titanium dioxide (TiO<sub>2</sub>). Solution plasma process (SPP), known for its speed, mild conditions, and efficacy, emerges as a superior method for CD synthesis. This study, TiO<sub>2</sub>-doped CDs were synthesized using SPP, enhancing their efficiency compared to conventional methods by producing a broader range of multi-functional groups, as confirmed by EDX-XRD analysis. The properties of TiO<sub>2</sub>-doped CDs were evaluated using XRD, Raman, and SEM techniques. These TiO<sub>2</sub>-doped CDs exhibit promise in enhancing the photocatalytic degradation of methylene blue compared to commercial TiO<sub>2</sub>.

**Keywords:** Carbon dots, Glucosamine, Fluorescent, Solution plasma process, Photocatalyst

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## Recycled graphite from spent Zn-C batteries for Li-ion batteries

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Batteries are essential in many fields and are in high demand. With production rising yearly, much of the battery waste is not recycled and is thrown away, especially the graphite in Zn-C batteries, which remains intact after use but is not recycled due to cost. This can harm the environment due to the impurities and also can hinder the battery's performance when graphite is used for the Li-ion battery from spent batteries.

The main impurity in recycled Zn-C batteries is silica. Acid and/or base treatment is suggested to remove it, but at the same time, it introduces different types of functional groups on the graphite surface and reduces its crystallinity. Several studies have reported the impacts of these surface treatments to improve battery performance. Based on this evidence, a combined approach is proposed to remove impurities and improve performance.

X-ray diffraction (XRD), X-ray fluorescence (XRF), and Raman spectroscopy were measured to determine the kind of impurities in recycled graphite and to evaluate the crystallinity and chemical bonding. Both rate tests and galvanostatic cycling were performed to evaluate battery performance. This research suggests methods to not only recycle graphite in batteries but also achieve higher performance and efficiency.

**Keywords:** Lithium-ion battery, Carbon Recycling

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**Investigation on Possibility to Anticipate Corrosion Behavior of Pipelines in Supercritical CO<sub>2</sub> with Water as Impurity Using Moderate Carbonate Solutions**

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Carbon dioxide (CO<sub>2</sub>) transportation is an important technology in the carbon capture, utilization and storage (CCUS) process and pipeline transportation of CO<sub>2</sub> in the supercritical state is considered as one promising technique. However, corrosion of pipelines, especially in the presence of impurities, has risen as a serious problem from the viewpoint of safety and economics. Unfortunately, evaluation of the corrosion resistance of such pipelines is difficult due to the extreme conditions associated with supercritical CO<sub>2</sub>, and an easier and safer method to evaluate such corrosion behaviors is desired. Here, we report on our preliminary investigation using carbonate solutions, such as ammonium bicarbonate (NH<sub>4</sub>HCO<sub>3</sub>). The study explores the corrosion behavior by electrochemical methods and material characterization in carbonate solutions under various conditions, targeting to anticipate the influence of water (H<sub>2</sub>O) as an impurity. Substrates with electroless nickel-phosphorus (Ni-P) plating are selected as the model for pipeline surface because it is one of the most promising corrosion protection strategies. The present preliminary study shall clarify the limitations of using carbonate solutions as a representative of supercritical CO<sub>2</sub> and shall provide insights on the possibility to anticipate corrosion behavior on electroless Ni-P plated surfaces under a supercritical CO<sub>2</sub> environment.

**Keywords:** Supercritical CO<sub>2</sub>, Corrosion, Carbonate solutions, Electroless Ni-P Plating

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## Phosphorus Recovery Using Magnetic Mg-Fe Layered Double Hydroxide

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Phosphorus is the cause of eutrophication and it is also an essential element for fertilizers. However, unfortunately, a vast amount of phosphorus is disposed of in the sewage. Therefore, removal and recovery of phosphorus are desired. One promising method to remove and recover phosphorus may be to apply layered double hydroxide (LDH); an anion exchanger, because phosphorus usually exists as oxyanions in aquatic environments. However, LDH shows difficulty to collect after the treatment because it is generally used in powder form and is well-dispersed in media. Embedment of magnetic particles is a promising technique to enable the collection of LDH using external magnetic fields. Here, magnetic LDH was synthesized using Na<sub>2</sub>CO<sub>3</sub> solution and a mixture of MgCl<sub>2</sub> and FeCl<sub>3</sub> solutions containing magnetite (Fe<sub>3</sub>O<sub>4</sub>) and its performance was evaluated. The material characterization results showed that magnetic LDH composed of Fe<sub>3</sub>O<sub>4</sub> and LDH has been obtained by synthesizing LDH in the presence of Fe<sub>3</sub>O<sub>4</sub>. The prepared magnetic LDH worked with the same adsorption mechanism as that of pristine LDH, and the adsorption performance of the LDH itself in the magnetic sample was almost maintained. Moreover, the magnetic LDH could be recovered in a few minutes by using a neodymium magnet.

**Keywords:** Phosphorus adsorption, LDH, magnetic separation



# Oral Presentation Abstract

**19 January 2024**

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## Development of Hexagonal Tungsten Oxide Membranes for Energy Saving Separation Processes

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Separation is one of the most energy consuming processes in industry, and separation membranes that allow separation at a molecular level are attracting increasing attention as a tool to reduce the energy of such processes. Indeed, membranes have been installed in numerous processes until now; however, almost all membranes are polymeric. Recently, microporous inorganic crystals, also known as molecular sieves, have been reported to be promising candidates for separation membrane materials, exceeding the trade-off relation of conventional polymeric membranes. Among them, hexagonal tungsten oxide is found to be a potential membrane material by our group, owing to its uniaxial pores parallel to its c-axis. Here, our challenges in synthesizing dense c-plane oriented hexagonal tungsten oxide membranes on porous alumina supports and experimental results showing its possibility to apply to liquid/liquid and gas/gas separation are introduced. The prepared membrane was capable of selectively separating water from water/acetic acid mixtures with low pH. Furthermore, the measurement of permeance of various single components, including both liquid and gas molecules, implied that the separation mechanism of the membrane was molecular sieving. The membrane seemed to be suitable for separating small molecules and may contribute to realizing a carbon-neutral and sustainable society.

**Keywords:** Hexagonal tungsten oxide, micropores, separation membrane, molecular separation  
**Acknowledgement:** This work was supported by JSPS-KAKENHI [JP22K14529] and JST-SICORP [JPMJSC18H1].

## High-Entropy Titanate-Based Perovskite Oxides for High Performance Ceramic Capacitors

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High-entropy oxides (HEOs), also known as entropy-stabilized oxides, have recently been investigated by scientific communities due to their unique characteristics. Initially, it was explored in alloy families as high-entropy-alloy (HEAs), in which high configurational entropy is a key factor in governing the stabilization of single-phase multi-cation compounds. Recent studies have shown that HEOs can be successfully synthesized by simple techniques and stabilized in various structures such as rock salt, pyrochlore, perovskite, spinel, and fluorite. In this study, we focus on HEOs that are stabilized in the perovskite structure based on  $ATiO_3$ , in which A is cations (5 or more) persisting similar ionic radii. Phase identification and crystal structure analysis revealed that a single-phase perovskite could be obtained. A-site sublattice modification could alter the dielectric properties of the compound. Similarly, B-site sublattice doping, such as Fe or Mn, with single-phase perovskite could be achieved. However, structural distortion was found to be more prominent in B-site sublattice modification than that of A-site sublattice modification. Based on this study, HEOs with perovskite structure require further investigation due to its flexibility in chemical manipulation and structural modification, which could lead to high-performance materials for sustainable applications.

**Keywords:** High-Entropy Oxides, Titanate-Based, Perovskite, Dielectric

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**Optimized synergistic effects of NiCu catalyst for ammonia oxidation reaction****Uijun Kim<sup>a</sup>, Seunghyo Lee<sup>a, \*</sup>**

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Hydrogen is a promising candidate energy and the ideal fuel since it only produces water when consumed by a fuel cell. However, the advent of the hydrogen economy cannot be realized until technical barriers related to hydrogen transportation, distribution, and storage are overcome.

Alternatively, ammonia has recently gained eminence due to its high hydrogen storage capacity, liquid state near ambient conditions, existing infrastructure, and supply chain, only producing oxygen and nitrogen. In addition, the energy theoretically required in ammonia electrolysis (0.06 V) is 95% less than the required energy cost in water electrolysis (1.23 V) for hydrogen production.

Although Pt-based catalysts are currently used to overcome the sluggish reaction rate of ammonia oxidation reaction (AOR), challenges still remain a hindrance, including poisoning and limited resources.

Herein, non-noble NiCu catalysts for AOR were synthesized by a solution plasma process to suggest efficient and cost-effective catalysts. The ratio of Ni to Cu was controlled to optimize the synergistic effects of NiCu catalyst by physically mixing Ni catalyst and Cu catalyst or synthesizing in Ni-based plasma reaction field and Cu-based plasma reaction field.

**Keywords:** Solution Plasma Process, Ammonia Oxidation Reaction, Non-noble Catalysts, Net Zero, Green Hydrogen

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**A Study on Magnetic Dual Z-Scheme Heterojunction as an Efficient  
Visible-Light-Driven System for Pollutant Degradation  
: Liquid Phase Plasma Synthesis**

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Photocatalytic technology has gained prominence in the 21st century due to environmental concerns and energy shortages. TiO<sub>2</sub> and ZnO photocatalysts, known for stability and affordability, face limitations with wide band gaps hindering solar energy utilization. Recent research enhances defect structures in these materials, aiming to broaden the photoresponse range and improve charge mobility. However, single-component photocatalysts encounter challenges in balancing strong redox capabilities with a broad photoresponse range. Heterogeneous photocatalysts, especially Z-Scheme heterojunctions, offer advantages in inhibiting recombination and maintaining robust redox capabilities to resolve these issues. Despite Z-Scheme heterojunctions offering superior performance, challenges arise from their small particle size, complicating recovery. However, the use of iron oxides simplifies recovery and recycling while enhancing electron-hole pair activity.

This study seeks to fabricate a photocatalyst with an extended light absorption range, suppressed recombination, strong redox capabilities, and efficient recovery. Defective TiO<sub>2</sub>[TO], C-Zn/ZnO[C-ZZO], and Fe/FeO/Fe<sub>3</sub>O<sub>4</sub>[FFO] photocatalysts are synthesized, followed by post-treatment to create a C-ZZO/TO/FFO nanocomposite. The synthesized nanocomposites are analyzed for material properties, and the photocatalyst's performance is evaluated through the degradation of Methylene Blue and Tetracycline. In summary, this research provides insights into applying a recyclable nanocomposite photocatalyst for real-world pollutant treatment, emphasizing the mechanism of the Dual Z-Scheme structure.

**Keywords:** Dual Z-Scheme; Defect; Magnetic recyclability; Nanomaterial; Liquid phase plasma

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**Nano-Sized  $\text{Cu}_x\text{Ni}_y$  based alloy via Solution Plasma Sputtering for Fuel Cell Catalysis****Yifu Ke<sup>a</sup>, Jiangqi Niu<sup>a</sup>, Nagahiro Saito<sup>a, b, c, d, e, \*</sup>**<sup>a</sup>Department of Chemical Systems Engineering, Graduate School of Engineering, Nagoya University, Furo-cho, Chikusa-ku, Nagoya, 464-8603, Japan<sup>b</sup>Institute of Materials Innovation, Institutes of Innovation for Future Society, Nagoya University, Furo-cho, Chikusa-ku, Nagoya, 464-8601, Japan<sup>c</sup>Conjoint Research Laboratory in Nagoya University, Shinshu University, Furo-cho, Chikusa-ku, Nagoya, 464-8603, Japan<sup>d</sup>Japan Science and Technology Corporation (JST), Open Innovation Platform with Enterprises, Research Institute and Academia (OPERA), Furo-cho, Chikusa-ku, Nagoya, 464-8603, Japan<sup>e</sup>Japan Science and Technology Corporation (JST), Strategic International Collaborative Research Program (SICORP), Furo-cho, Chikusa-ku, Nagoya, 464-8603, Japan

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In the context of global decarbonization, fuel cell technology represents a promising and sustainable avenue for energy conversion. This technology directly converts fuel into electricity without combustion, which substantially decreases CO<sub>2</sub> emissions compared to traditional energy sources. Fuel cells are versatile and can operate on diverse fuels, including hydrogen, methanol, and natural gas. However, the commercialization of fuel cells is often hindered by the cost and scarcity of noble metal catalysts, such as platinum. Therefore, there is a critical demand for the development of noble metal-free catalysts that can simultaneously reduce costs and minimize environmental impact. In this research, the noble metal-free contained catalyst which is nano-sized copper-nickel ( $\text{Cu}_x\text{Ni}_y$ ) alloy was fabricated via solution plasma sputtering (SPS) under extreme pH conditions and it has shown the potential application in fuel cell catalysis. To prepare the  $\text{Cu}_x\text{Ni}_y$  alloy, an aqueous solution of the respective metal salts was subjected to a high voltage electric discharge under extreme pH conditions both acidic (below pH 3) and alkaline (above pH 10), which offers a unique advantage in suppressing the oxidation rate of copper or nickel during synthesis. The rapid electron transfer from the plasma to the solution initiates the reduction of metal ions, leading to the formation of nano-sized  $\text{Cu}_x\text{Ni}_y$  particles. Further, it also underscores the influence of the synthesis conditions on the catalyst's performance. By controlling the pH during SPS, it was possible to regulate the composition of metals, thereby influencing the structural and electrochemical properties of the synthesized  $\text{Cu}_x\text{Ni}_y$  alloy nanoparticles. In conclusion, the findings of this research represent a significant stride towards the development of cost-effective, efficient, and environmentally friendly fuel cell catalysts. The successful synthesis of nano-sized  $\text{Cu}_x\text{Ni}_y$  based alloy under extreme pH conditions through SPS, alongside its enhanced catalytic activity, paves the way for future research and application in the renewable energy sector.

**Keywords:** Copper-nickel alloy, Solution plasma, Fuel cell

## Synthesis of Molybdenum Disulfide Thin Films by Combination of Spin Coating Method and Heat Treatment

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Molybdenum disulfide (MoS<sub>2</sub>) with a hexagonal layered crystal structure is attracting attention as an alternative semiconductor material to Si and graphene because of its high carrier mobility and innate band gap. Various methods have been developed in previous studies, such as chemical vapor deposition (CVD) and dip-coating methods. However, CVD and dip-coating methods have a limitation on the uniform thickness, and most methods require a sulfurization process, which needs an excessive amount of sulfur (S) to achieve large continuous films. In this study, we proposed a single solution containing S and ammonium thiomolybdate (NH<sub>4</sub>)<sub>2</sub>MoS<sub>4</sub> to reduce the amount of S used in the process. The solution was coated on the substrate by a spin-coating method, which shows the potential to control the thickness and uniformity of the thin film prior to heat treatment. According to Raman and SEM, the different ratios of S/Mo, which were adjusted by the amount of S dissolved in the solution, led to different thicknesses, sizes, and shapes (e.g., triangle, round) of domains and morphology (two-dimensional and three-dimensional domain).

**Keywords:** Molybdenum disulfide, Spin coating, Heat treatment

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## Polydiacetylene-based Nanocomposites for Colorimetric Detection of Acid-Base in Food Products

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Developing polydiacetylenes (PDAs) for colorimetric sensing applications involves incorporating foreign materials, for example, ions, nanoparticles, surfactants and polymers. For PDA/Zn<sup>2+</sup>/ZnO nanocomposites, reversible thermochromism, dual colorimetric responses to acid and base and color stability in organic solvents are among their exceptional characteristics. This research explores the applications of PDA/Zn<sup>2+</sup>/ZnO nanocomposites as colorimetric sensors for detecting organic acid-base in various organic solvents and food products. Fine-tuning of the sensitivity can be achieved by varying the ZnO ratios and monomer structures. The ability to control the sensitivity allows the utilization of the nanocomposites for semi-quantitative analysis of acid-base in food products. Solid-state sensors can be fabricated by embedding in nylon filters. Quality control of fruit juices and the freshness of milk can be indicated via naked-eye detection. Our study expands the applications of PDA materials as colorimetric sensors for food industries to reduce unnecessary food loss and health risks for consumers.

**Keywords:** Polydiacetylene, Colorimetric sensors, Acid-base sensors



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## Solution Plasma synthesis of Pt-Y Alloy Nanoparticle its Catalytic Property for Oxygen Reduction Reaction

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Proton Exchange Membrane Fuel Cells (PEMFCs) face a critical challenge in the sluggish Oxygen Reduction Reaction (ORR) kinetics at the cathode, hindering widespread use. Platinum (Pt), the conventional ORR catalyst, is scarce and costly, prompting the search for alternatives. Platinum-yttrium (Pt-Y) alloy, especially Pt<sub>3</sub>Y intermetallic compound, is considered to have superior ORR activity while maintaining stability based on existing calculations [1]. However, Y's negative reduction potential complicates traditional methods. This study proposes a new approach: Pt-Y nanoparticle synthesis in the participation of the solution plasma process (SPP). This method utilizes a high-energy reaction field, generating Pt-Y nanoparticles through metal electrode sputtering. Carbon black can be added during SPP as support, enabling a simplified one-pot synthesis. To address Y Oxides in samples prepared by SPP, adding CaH<sub>2</sub> and heating in a tube furnace [2] to reduce Y and promote alloying.

The Pt-Y alloy emerges as a promising ORR catalyst in PEMFCs, balancing performance and cost considerations. Further research into this synthesis approach and alloying mechanism holds the potential for advancing PEMFCs in clean energy systems.

**Keywords:** Proton Exchange Membrane Fuel Cells, Oxygen Reduction Reaction, catalyst, Platinum-yttrium alloy, Solution plasma process

# Poster Presentation Abstract

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**Preliminary investigation of fructose dehydration to 5-hydroxymethylfurfural using Amberlyst-15, H-ZSM-5, H-USY and H- $\beta$  Zeolite in a biphasic medium**

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The strategy of converting biomass into high-value chemicals holds significant promise for sustainable development in a bio-based economy. 5-Hydroxymethylfurfural (HMF) serves as a fundamental biomass-derived platform chemical, contributing to the production of renewable fuel additives, liquid hydrocarbon fuels, and value-added chemicals like 2,5-furandicarboxylic acid (FDCA) for use in bioplastics. This study conducted a comparative analysis utilizing various Brønsted acid catalysts such as Amberlyst-15, H-ZSM-5, H-USY and H- $\beta$  Zeolite acting as heterogeneous catalysts in the dehydration of fructose to HMF in a biphasic water/tetrahydrofuran solvent medium. The findings aim to present an effective approach for dehydrating fructose to HMF, potentially facilitating the efficient production of FDCA.

**Keywords:** fructose; 5-hydroxymethylfurfural; Amberlyst-15; H-ZSM 5; H-USY and H- $\beta$  Zeolite

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## Isolation of intermediates and investigation of reaction mechanism in the synthesis of evaporable fullerene derivatives

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Indano[60]fullerene ketone, with its unique structure, has garnered attention as an evaporable fullerene derivative with potential applications in next-generation organic semiconductors. However, the low reproducibility in the final reaction has been a significant issue in the synthesis of indano[60]fullerene ketone. In this research, we identified the cause of the decreased reaction yield of indano[60]fullerene ketone as a newly discovered intermediate, indano[60]fullerene bromide. During the synthesis of indano[60]fullerene ketone from methoxy indano[60]fullerene or its precursor aryl[60]fullerenyl dimer, a specific byproduct was observed. By focusing on this byproduct and conducting measurements using <sup>1</sup>H-NMR and HRMS, we elucidated its structure. The analysis revealed that the byproduct is indano[60]fullerene bromide. Furthermore, based on this intermediate, we investigated the reaction mechanism for the generation of indano[60]fullerene ketone from methoxy indano[60]fullerene. From this mechanistic study, we determined to use hydrobromic acid as a mediator in the reaction. As a result, it was determined that the addition of hydrobromic acid enabled a sequential and stable reaction to produce indano[60]fullerene ketone from methoxy indano[60]fullerene via indano[60]fullerene bromide. Finally, we achieved an 89% isolated yield in the series of reactions from methoxy indano[60]fullerene to indano[60]fullerene ketone stably.

**Keywords:** organic semiconductor, fullerene derivatives, intermediates, organic synthesis

**Ti-Fe<sub>2</sub>O<sub>3</sub>/Ni(OH)<sub>x</sub> as an efficient and durable photoanode for the photoelectrochemical catalysis of PET plastic to formic acid****Xin Li**<sup>a</sup>, Jianying Wang<sup>a</sup>, Mingze Sun<sup>a</sup>, Xufang Qian<sup>a</sup>, Yixin Zhao<sup>a, b, \*</sup><sup>a</sup>School of Environmental Science and Engineering, Shanghai Jiao Tong University, Shanghai 200240, China<sup>b</sup>Shanghai Institute of Pollution Control and Ecological Security, Shanghai 200240, China

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Photoelectrochemical (PEC) technology provides a promising prospect for the transformation of polyethylene terephthalate (PET) plastic wastes to produce value-added chemicals. The PEC catalytic systems with high activity, selectivity, and long-term durability are required for future large-scale industrial applications. Herein, we employed the interfacial modification strategy to develop an efficient and stable photoanode and evaluated its PEC activity for the valorization of PET plastic wastes into formic acid. The interfacial modification between Fe<sub>2</sub>O<sub>3</sub> semiconductor and Ni(OH)<sub>x</sub> cocatalyst with ultrathin TiO<sub>x</sub> interlayer not only improved the photocurrent density by accelerating the kinetics of photogenerated charge carriers but also kept the high Faradaic efficiency (over 95% in 30 h) towards the value-added formic acid product. This work proposes an effective method to promote PEC activity and enhance the long-term stability of photoelectrodes for upcycling PET plastic wastes.

**Keywords:** Plastic waste; Formic acid; Photoelectrochemical catalysis; High durability; Interfacial modification

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**Electrocatalytic CO<sub>2</sub> Reduction Coupled with Poly(ethylene terephthalate) Plastic Valorization for Simultaneous Production of Formate**Yan Fang<sup>a</sup>, Chengcheng Cai<sup>a</sup>, Xufang Qian<sup>a, \*</sup>, Yixin Zhao<sup>a, \*</sup><sup>a</sup>School of Environmental Science and Engineering, Shanghai Jiao Tong University, Shanghai 200240, P. R. China

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Electrocatalytic reduction of CO<sub>2</sub> into useful fuels provides a green strategy to mitigate energy crisis and climate change issues. As the anodic oxygen evolution reaction (OER) in CO<sub>2</sub> electrolysis system always exhibits high overpotential, leading to large cell voltage and energy consumption, it is sensible to replace the OER with some organic oxidation reactions. Herein, we report a novel electrocatalytic system to valorize CO<sub>2</sub> and poly(ethylene terephthalate) (PET) plastic to produce formate on both electrodes. The Bi<sub>2</sub>O<sub>3</sub> electrocatalyst achieves excellent CO<sub>2</sub> conversion to formate with a high Faradaic efficiency above 90% from -0.8 V<sub>RHE</sub> to -1.2 V<sub>RHE</sub> and 20 h retention of 45 mA/cm<sup>2</sup> at -1.0 V<sub>RHE</sub>. The anodic NiOOH electrocatalyst displays a Faradaic efficiency above 85% from 1.4 V<sub>RHE</sub> to 1.8 V<sub>RHE</sub> to convert PET hydrolysate into formate. By utilizing two electrocatalysts for the cathode and the anode, respectively, we obtain a coupled system to produce formate efficiently, and the accumulated formate Faradaic efficiency is above 180% for two electrodes with the cell voltage ranging from 2.0 V to 2.6 V. Such a system which could operate under a wide potential range with very high efficiency provides an energy-efficient route to realize the production of desired value-added chemicals.

**Keywords:** electrocatalytic CO<sub>2</sub> reduction, plastic upcycling, coupled system, value-added chemical production

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## Heteroatom-doped MoC/C Nanocomposite Synthesized by Liquid Phase Plasma for Electrochemical Ammonia Production

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As the global economy becomes a hydrogen economy and carbon neutrality, developing renewable, sustainable, and clean energy is indispensable. Ammonia (NH<sub>3</sub>) is one of the most effective energy storage media for several reasons, including its high weight fraction of hydrogen, mild liquefaction conditions, and ease of decomposition to produce high-purity hydrogen. Hence, the synthesis of ammonia by the electrochemical reaction of water and nitrogen at low temperatures and low pressure has become an emerging and active research topic. Nevertheless, due to the restriction of inert N≡N fracture, which requires a relatively high-energy barrier and hydrogen evolution reaction selectivity, it is crucial to pick the right electrocatalysts. Density functional theory has demonstrated that molybdenum offers excellent performance in activating N<sub>2</sub> molecules and stabilizing \*N<sub>2</sub>H intermediates while destabilizing \*NH<sub>2</sub> species during nitrogen reduction reaction (NRR). Molybdenum carbides (MoC) exhibit high adsorption capacity for N<sub>2</sub> and catalytic hydrogenation ability. Moreover, doping of carbon nanomaterials with heteroatoms would achieve electron-donor properties and improved π bonding in adjacent framework, leading to the tailored electrocatalytic property.

In this study, heteroatom-doped MoC/C electrocatalysts were synthesized by liquid phase plasma for NRR. To enhance the NRR catalytic activity, several types of heteroatoms are doped on MoC/C electrocatalysts.

**Keywords:** Nitrogen Reduction Reaction, Liquid Phase Plasma, Molybdenum Carbide, Carbon Nanocomposite

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## High Efficient Decomplexation of Cu-EDTA and Subsequent Cu Removal by Liquid Phase Plasma

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EDTA, a common industrial agent, is extensively used in electroplating, metallurgy, and other industries to stabilize heavy metal ions. However, the use of EDTA can have detrimental effects on human health and the ecosystem due to the formation of EDTA-heavy metal complexes, such as Cu-EDTA, which are highly toxic, persistent, and mobile. Although several traditional methods have been adopted to degrade the complexes, challenges lie ahead, such as long treatment times and the need for a large installation area.

Recently, liquid phase plasma (LPP) has attracted great attention for pollution treatment due to its high removal efficiency, simple equipment, and mild operating conditions at room temperature and atmospheric pressure. Therefore, the aim of this research was to probe the performance and mechanism of Cu-EDTA decomplexation by the LPP process; influences of initial pH and concentration on Cu-EDTA decomplexation were particularly investigated.

The electrical characteristics of LPP were investigated using an oscilloscope. Concentrations of Cu-EDTA were measured by HPLC and a UV/Vis spectrometer. OES and FTIR were used to investigate the decomplexation mechanism. After LPP treatment, the solution pH was adjusted to 11 using a NaOH solution to collect the precipitates and then prepared for chemical composition analysis.

**Keywords:** Cu-EDTA, Liquid phase plasma, Decomplexation, Chemical precipitation



## Evaluation of Stress Corrosion Cracking Behaviors for Cu Alloy in Diverse Environments

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Copper is commonly applied to domestic and industrial fields, including heat exchanger tubes and pipes, due to its high thermal conductivity. Copper forms a passive film, such as Cu<sub>2</sub>O or CuO, enhancing corrosion resistance.

Cu-DHP, known as copper deoxidized high residual phosphorus (P), is pure copper deoxidized with 0.004~0.012% P to resist hydrogen embrittlement. However, it is susceptible to stress corrosion cracking (SCC) in specific corrosive environments, which can lead to failures and leakage.

On the other hand, while it is known that additions of tin (Sn) in brass improve dezincification resistance, the effects of Sn in pure copper on corrosion resistance and SCC have not been sufficiently studied yet.

Herein, the corrosion resistance and SCC behaviors of Cu-DHP and Cu-Sn alloy in diverse environments were investigated. In order to evaluate SCC resistance, the U-bend test was performed by stressing the copper pipe with bolt-nut fastening and immersing it in 3.5 wt.% NaCl, 5 wt.% NH<sub>3</sub>, 5 wt.% H<sub>2</sub>SO<sub>4</sub>, and 1 wt.% HCOOH solutions. Additionally, SCC resistance was analyzed using OM, FE-SEM, and EDS. Moreover, EBSD analysis studied crack growth behavior. Potentiodynamic polarization test was conducted in each solution to analyze the corrosion resistance properties.

**Keywords:** Cu-DHP, Cu-Sn alloy, stress corrosion cracking (SCC), NaCl, NH<sub>3</sub>, H<sub>2</sub>SO<sub>4</sub>, HCOOH, immersion, U-bending

## Characterization of the Corrosion Behavior on Nitrogen-Containing Austenitic Stainless Steel: Performance of Repassivation

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Austenitic stainless steel (ASS) exhibits excellent corrosion resistance due to the formation of primary and secondary passive films. However, the passive film is prone to be destroyed in wet environments containing chloride ions (Cl<sup>-</sup>), then pits are deepened due to the local dissolution of the alloy matrix. Three stages of pitting corrosion can be distinguished: (1) pit nucleation; (2) formation of metastable pits, which inhibit growth by the self-healing process; and (3) growth of stable pits that dissolve passive film continuously.

On the other hand, Nitrogen (N), a strong austenitic stabilizer, increases microstructural homogeneity and promotes repassivation improving corrosion resistance. In addition, N has a good influence on the semiconducting properties of the passive film. The Point Defect Model is based on the fact that an oxide film is highly defective, including oxygen vacancies and metal vacancies. When the Cl<sup>-</sup> is adsorbed on the film and permeated into the surface oxygen vacancies, a metal ion dissolution occurs, and then the concentration of the metal vacancy is excessively increased to generate a pitting corrosion. Therefore, the purpose of this study is to evaluate the corrosion behavior of passive film of nitrogen-containing austenitic stainless steel (NASS) and 304 stainless steel.

**Keywords:** Nitrogen, Electrochemical corrosion resistance, Pitting corrosion, Passive film, Self-healing, Repassivation



