シンポジウム | アジア国際シンポジウム：アジア国際シンポジウム―ナノテク・材料化学ディビジョン／資源・エネルギー・地球化学・核化学・放射化学ディビジョン―

2026年3月19日(木) 9:00 ~ 11:40 | A1422（14号館 [2階] 1422）

## [A1422-3am] アジア国際シンポジウム―ナノテク・材料化学ディビジョン／資源・エネルギー・地球化学・核化学・放射化学ディビジョン―

座長，シンポジウム関係者：上野 貢生（北海道大学）、山内 美穂（九州大学）、伊藤 省吾（兵庫県立大学大学院）、久保 貴哉（東京大学）、岡 伸人（近畿大学）、山方 啓（岡山大学）、豊田 栄（東京科学大学）、渡邉 雅之（（国）日本原子力研究開発機構）

**本セッションは午前、午後に実施されます。**

英語 Invited Lecture
9:00 ~ 9:20
[A1422-3am-01] 動的分子マシンと配位分子鎖による光機能プログラミング
○豊田 良順[1] (1.東北大学)

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英語 Invited Lecture
9:20 ~ 9:40
[A1422-3am-02] 液相プロセスによる高機能電極の創生とその界面電荷移動過程の解明
○南本 大穂[1] (1.神戸大学)

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英語 Keynote Lecture
9:40 ~ 10:10
[A1422-3am-03] Small-Molecule Alkali-Modified HTLs Coupled with Powder-Encoded Perovskites for Stable, Solvent-Lean Device Fabrication
○GYUMIN KIM[1], Tsutomu Miyasaka[2] (1.Hankyong National University, 2.Toin University of Yokohama)

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10:10 ~ 10:30
休憩

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英語 Invited Lecture
10:30 ~ 10:50
[A1422-3am-04] 可視光水分解用層状複合アニオン光触媒の開発
○鈴木 肇[1,2] (1.京都大学、2.JSTさきがけ)

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日本語 Invited Lecture
10:50 ~ 11:10
[A1422-3am-05] ペロブスカイト太陽電池の高耐久性化を目指した分子設計戦略と界面制御
○松島 敏則[1] (1.九州大学)

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英語 Keynote Lecture
11:10 ~ 11:40
[A1422-3am-06] Two Dimensional Transition Metal Dichalcogenide-based Reconfigurable Memristors operated by Surface Acoustic Waves
○IL JEON[1] (1.Sungkyunkwan University (SKKU))

# Programming Photofunctions with Dynamic Molecular Machines and Coordination Nanochains

(*Graduate School of Science, Tohoku University*) ○Ryojun Toyoda
**Keywords**: Molecular Machines; Nanomaterials; Photochemistry; Coordination Chemistry; Photoluminescence

Light-driven molecular machines can induce mechanical movements upon photoirradiation. Therefore, integrating these components into materials is a promising strategy for achieving dynamic photofunctions. This talk introduces two research topics, demonstrating the utility of molecular machines for precise chiroptical control and proposing a technique to enhance their photosensitivity for practical applications.

In the first topic, molecular machines together with achiral photoluminescent dyes have been introduced within liquid crystal (LC) hosts as stimuli-responsive chiral dopants, where the helicity of the machine is efficiently transferred to the LC host.[1] Upon light irradiation, the molecular machines can switch the handedness of their helicity and therefore dictate the handedness of the helical assembly of LC molecules reversibly. This co-assembled system exhibited intense, reversible CPL with a change of $g_{lum}$ value from −0.4 to +0.4. This change is so distinct that it is visible to the naked eye through a circular polarizer. This approach allows for programmable switching and tunable emission colors, paving the way for next-generation optoelectronic devices.

For such molecular machines to function in materials or biological environments, they are requested to operate efficiently under weak light. By engineering one-dimensional multinuclear metal complexes that act as exciton-transporting nanochains,[2] we have developed nature-inspired light-harvesting systems. When an azobenzene photoswitch is attached to the terminus of this nanochain, harvested energy migrates along the scaffold and funnels into the photoswitch. This mechanism enables photoisomerization with unprecedented photosensitivity, allowing molecular machines to actuate even in low-light environments.[3]

These advancements, ranging from programmable chiroptical switching to energy-harvesting scaffolds, provide a strategic foundation for designing a new class of dynamic nanomaterials capable of advanced photofunctions.

1) J. Hou, R. Toyoda, S. C. J. Meskers, B. L. Feringa, *Angew. Chem. Int. Ed.* **2022**, *61*, e202206310. 2) R. Toyoda, N. Fukui, H. Taniguchi, H. Uratani, J. Komeda, Y. Chiba, H. Takaya, H. Nishihara, R. Sakamoto, *Nat. Commun.* **2025**, *16*, 1367. 3) Y. Chiba, R. Shoji, K. Mira, S. Takaishi, S. Sakamoto, R. Toyoda, *in revision.*

# Preparations of Highly Active Electrodes via Aqueous-Phase Processing with Elucidation of Charge-Transfer Mechanisms

(*Department of Chemical Science and Engineering, Graduate School of Engineering, Kobe University*) ○Hiro Minamimoto

**Keywords**: *semiconductor electrodes*; liquid phase deposition methods; photoelectrochemistry; light energy conversion

Efficient light energy conversion is a crucial technique for achieving a sustainable society. Since the discovery of the Honda-Fujishima effect, a variety of semiconductors have been investigated as potential materials for light-energy conversion. To date, chemically stable oxide films have been engineered as photoconversion electrodes. However, the preparation methods for these semiconductor materials frequently depend on relatively high-energy processes. Consequently, there is an urgent demand for simpler, low-energy methods that ensure consistent reproducibility. In response to this need, we have developed an aqueous solution-based inorganic synthesis technique known as liquid phase deposition (LPD). By utilizing the LPD method,[1, 2] we have successfully synthesized a range of metal oxides, including such as the tungsten or titanium dioxides.[1, 2] Additionally, we have optimized the reaction conditions to improve the efficiency of light energy conversion.

In our LPD method, we precisely controlled the equilibria of metal fluorine complexes to facilitate the deposition of various metal oxides or hydroxides. One of the key advantages of the LPD method is its ability to produce homogeneous thin layers with high crystallinity. Recently, we have developed new synthesis routes within the LPD framework for the preparation of tungsten oxide ($WO_3$) and zinc oxide ($ZnO_2$).[3] By investigating the reaction conditions, such as concentration and temperature, we successfully optimized these parameters to achieve $WO_3$ (Fig. 1) and $ZnO_2$ thin layers on the substrate surface, resulting in high crystallinity. Alongside surface analyses, we conducted electrochemical measurements to assess the surface electronic energy states and light response capabilities.

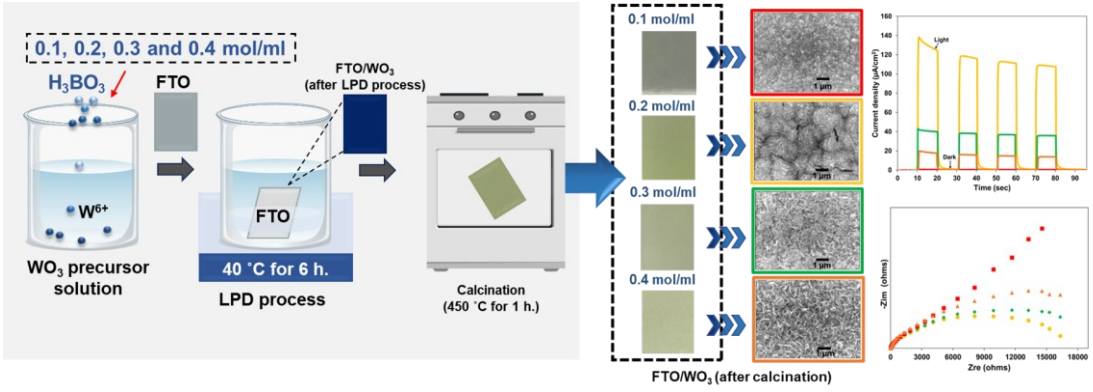



Fig. 1. Schematic illustrations of the preparation procedure of $WO_3$ films and their photoresponse abilities.

Our findings confirmed not only high reproducibility but also a significant light-energy conversion efficiency.

In addition to simple oxide films, we have explored the preparation of composite materials that combine semiconductor and metal nanoparticles. The chemically stable semiconductor materials possess a large band-gap energy, which restricts their activity to the ultraviolet region. To address this limitation, the introduction of metal structures that exhibit excitations of localized surface plasmon resonance (LSPR) has recently prepared.[4] Building on this foundation, we have developed a new LPD approach to synthesize a hybrid material that incorporates gold (Au) nanoparticles within titanium dioxide ($TiO_2$). In this method, we introduced Au ions into the reaction solutions. As a result, we confirmed the successful integration of Au nanoparticles within the $TiO_2$ layer. Our findings indicate that this composite material exhibits an enhanced response to visible light compared to conventional $TiO_2$ (Fig. 2). Through wavelength-dependent examinations, we established that this visible light response is due to the LSPR excitations on the Au nanoparticles. Furthermore, we optimized the reaction conditions to maximize photoconversion efficiency. Overall, our investigations highlight the significant potential of the LPD method as a preparation technique for materials intended for light energy conversion.[5]

Based on the aforementioned investigations, we have effectively elucidated the potential of the LPD method as a viable procedure for the preparation of light-responsive materials.

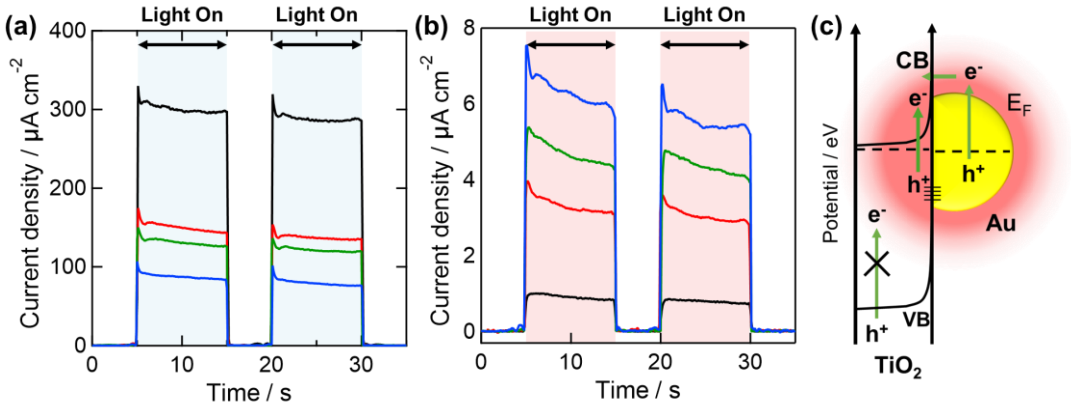



Fig. 2. Photoresponse abilities of Au nanoparticles-incorporated $TiO_2$ film obtained under (a) white and (b) visible light illuminations. (c) Schematic illustration of the charge transfer process on the prepared film.

H. Minamimoto *et al*., 1) *Electrochemistry* **2013**, *9*, 067005. 2) *ACS Electrochemistry* **2025**, *1*, 2034. 3) *ACS Omega* **2024**, *9*, 38788. 4) *J. Phys. Chem. C* **2016**, *120*, 16051. 5) *ACS Appl. Energy Mater.* **2026**, *9*, 233.

# Small-Molecule Alkali-Modified HTLs Coupled with Powder-Encoded Perovskites for Stable, Solvent-Lean Device Fabrication

([1]*Department of Chemical Engineering, Hankyong National University*, [2]*Graduate School of Engineering, Toin University of Yokohama*) ○ Gyu Min Kim,[1] Tsutomu Miyasaka[2]

**Keywords**: Perovskite solar cells; Dopant-free hole transport layer; Alkali metal incorporation; Mechanochemical synthesis; Solvent-lean fabrication

The development of perovskite solar cells (PSCs) requires both stable hole transport layers (HTLs) and scalable fabrication processes. In this study, we report a dual strategy using alkali modified sulfonic acid based small molecule HTLs and mechanochemically synthesized perovskite and HTL powders to enable stable and solvent lean device fabrication. The HTLs are based on a carbazole framework functionalized with sulfonic acid groups, where the acidic hydrogen is replaced by alkali metal cations including $Na^{+,}$ $K^{+}$, $Rb^{+}$, and $Cs^{+}$. These substitutions enhance interfacial dipole alignment, improve energy level matching, and eliminate the need for dopants.[1]

In addition, perovskite and HTL powders containing methylammonium chloride and Li TFSI were prepared via ball milling, offering uniform composition, long term storage stability, and reduced use of volatile solvents. The resulting powder based PSCs achieved power conversion efficiencies over 24% with minimal hysteresis, and demonstrated excellent stability under thermal and humidity stress.[2]

This combined approach addresses two key challenges in PSC commercialization, which are interfacial instability and process reproducibility. By integrating molecular level HTL engineering with solvent saving powder based fabrication, this work provides a promising platform for high performance PSCs suitable for industrial scale production with improved environmental compatibility.

1) H. Kim, *Chem. Eng. J*. **2025**, 505, 159571. 2) J. Kim, *Small* **2025**, 21, 23009799.

# Development of Layered Mixed-Anion Photocatalysts for Visible-Light-Driven Water Splitting

([1]*Graduate School of Engineering, Kyoto University*, [2]*Precursory Research for Embryonic Science and Technology (PRESTO), Japan Science and Technology Agency (JST)*)
○Hajime Suzuki[1,2]

**Keywords**: Photocatalyst; Visible light; Water splitting; Mixed-anion compound; Oxyhalide

Water splitting using semiconductor photocatalysts under solar light has attracted much attention as a promising method for clean hydrogen production. The effective utilization of visible light is one of the most important challenges to achieve the desired efficiency in practical application. We have recently shown that layered oxyhalide semiconductors with Sillén and Sillén–Aurivillius structures possess suitable band positions for visible-light-driven water splitting while maintaining high stability, because of their unique band structure.[1-3] These oxyhalides possess the layered structure consisting of an intergrowth of alternating the fluorite, perovskite, and halide layers; their photocatalytic properties (e.g., band structure and carrier dynamics) can be tuned by changing layers and stacking sequence of them. By combining DFT calculations with various time-resolved spectroscopic measurements, we have elucidated aspects of the structure-property-activity relationship. Furthermore, we have developed new synthetic methods: multi-step synthesis and flux synthesis, to obtain oxyhalide photocatalysts with multilayer perovskite and high crystallinity, respectively.[4,5] This presentation will provide an overview of our recent progress on oxyhalide photocatalysts, with particular focus on recent surface/interfacial engineering to promote the surface reactions in photocatalytic water splitting.

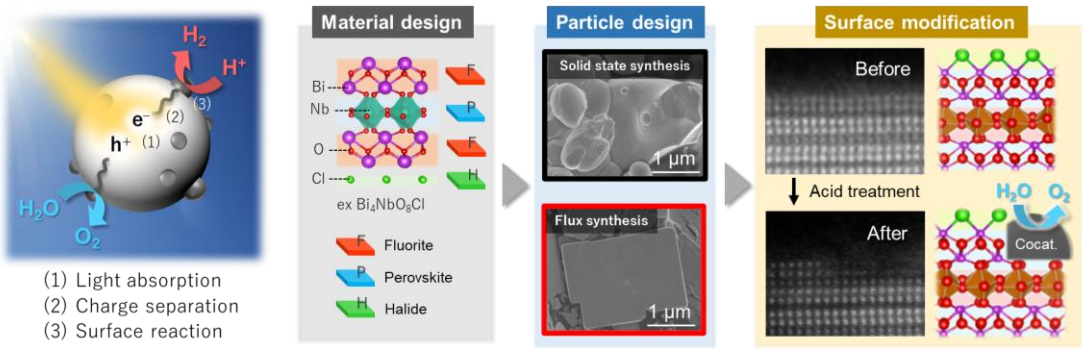



**Figure 1.** Conceptual image of water splitting using semiconductor photocatalysts and development scheme for oxyhalide photocatalysts for water splitting under visible light.

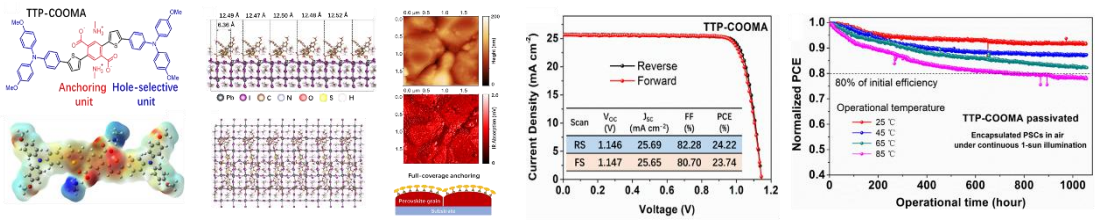
1) H. Fujito, H. Kunioku, D. Kato, H. Suzuki, M. Higashi, H. Kageyama, R. Abe, *J. Am. Chem. Soc.* **2016**, *138*, 2082. 2) H. Suzuki, H. Kunioku, M. Higashi, O. Tomita, D. Kato, H. Kageyama, R. Abe, *Chem. Mater.* **2018**, *30*, 5862. 3) D. Kato, H. Suzuki, R. Abe and H. Kageyama, *Chem. Sci.* **2024**, *15*, 11719. 4) K. Ogawa, A. Nakada, H. Suzuki, O. Tomita, M. Higashi, A. Saeki, H. Kageyama, R. Abe, *ACS Appl. Mater. Interfaces* **2019**, *11*, 5642. 5) D. Ozaki, H. Suzuki, K. Ogawa, R. Sakamoto, Y. Inaguma, K. Nakashima, O. Tomita, H. Kageyama, R. Abe, *J. Mater. Chem. A* **2021**, *9*, 8332.

# ペロブスカイト太陽電池の高耐久性化を目指した分子設計戦略と界面制御

（九大 WPI-I2CNER）○松島 敏則
Molecular Design Strategies and Interface Engineering for Durable Perovskite Solar Cells (International Institute for Carbon-Neutral Energy Research (WPI-I2CNER), Kyushu University) ○Toshinori Matsushima

In this talk, we review recent research progress and our own results from the perspectives of molecular design strategies and interfacial engineering, aiming to enhance the long-term durability of perovskite solar cells, which is one of the most critical challenges for their practical deployment. In particular, we focus on the passivation of crystal and interfacial defects using organic molecules, the chemical stabilization of charge-transport-layer/perovskite interfaces, and the suppression of ion migration and parasitic reactions at the $SnO_2$ electron-transport-layer interface. Furthermore, degradation processes occurring in both the bulk and at interfaces are elucidated through spectroscopic and electrical analyses, and the impact of molecular and interfacial structures designed on the basis of this understanding on device durability is demonstrated. Based on these insights, we discuss practical guidelines for durability-oriented design that integrate materials design, interfacial engineering, and device architecture to achieve both high efficiency and long-term operational stability.
*Keywords : Perovskite Solar Cells; Long-Term Durability; Functional Molecule; Defect Passivation; Interface Engineering*

本講演では、ペロブスカイト太陽電池の社会実装に向けて最も重要な課題の一つである長期安定性の向上を目的として、分子設計戦略および界面制御技術の観点から最近の研究動向と著者らの成果を発表する。特に、有機分子を用いた結晶欠陥および界面欠陥のパッシベーション、輸送層／ペロブスカイト界面における化学的安定化、ならびに $SnO_2$ 電子輸送層界面で生じるイオン移動や副反応の抑制に焦点を当てる。さらに、バルクおよび界面の双方で進行する劣化過程を分光・電気的解析により解明し、その理解に基づいて設計された分子および界面構造がデバイス耐久性に及ぼす影響を示す。これらの知見を踏まえ、材料設計、界面工学、ならびにデバイス構造を統合的に最適化することにより、高効率と高耐久性を両立するための実践的な耐久化設計指針について議論する。



# Fatigue-free Two Dimensional Transition Metal Dichalcogenide-based Reconfigurable Memristors operated by Surface Acoustic Waves

○IL Jeon[1,2,3]

[1] *Department of Nano Engineering, Department of Nano Science and Technology, SKKU Advanced Institute of Nanotechnology (SAINT), Sungkyunkwan University (SKKU), Suwon 16419, Republic of Korea*

[2] *SKKU Global Research Center (SGRC), Sungkyunkwan University (SKKU), Suwon 16419, Republic of Korea*

[3] *Research and Analytical Center for Giant Molecules, Graduate School of Science, Tohoku University, Sendai 980-8578, Japan*

Il.jeon@spc.oxon.org

**Abstract:** We present a reconfigurable $MoS_2$ memristor in which surface acoustic waves (SAWs) provide contactless, low-heat control of volatile, short-term-memory (STM) behaviour, while electrical bias programs stable non-volatile states. A monolayer $MoS_2$ channel is integrated between interdigital transducers on 128° YX-cut $LiNbO_3$; the device resonates at ~221.1 MHz. Post-annealing (400 °C, 1 h) introduces S-vacancy traps that enhance resistive switching: multilevel states, >1,100 DC cycles endurance, ~$10^3$ Ion/Ioff at 1 V read, and >$10^3$ s retention are achieved. SAW stimuli tune both postsynaptic current (PSC) and decay time via piezotronic coupling; responses scale with RF power and pulse width, and are maximised when the $MoS_2$ armchair axis aligns to SAW propagation. Open-circuit voltages measured at the channel confirm piezoelectric origin, while control experiments discount a dominant piezoresistive contribution. Crucially, SAW-induced volatile transients superimpose on, but do not overwrite, electrically written non-volatile levels, enabling independent, reversible operation and long-term stability under >10,000 s excitation. Leveraging the strain-tunable fading memory, we implement a physical reservoir computing scheme using 4-bit SAW temporal inputs to classify simple character patterns (‘J’, ‘L’, ‘A’, ‘b’) with ~96% test accuracy, comparable to a control reservoir; UMAP embeddings evidence enhanced class separability. This SAW-driven approach offers a CMOS-friendly route to fatigue-free, low-power, and fully reconfigurable synaptic hardware that unifies storage and processing within one device.

**Key words:** Two Dimensional Transition Metal Dichalcogenides, Reconfigurable Memristors,