SS3 : 수소 및 고부가가치 화합물 생산을 위한 차세대 광전 소재 및 소자

SS3-1 | Visible-Light-Responsive Perovskite Oxynitrides for Splitting of Water into Hydrogen and Oxygen

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Sunlight-driven (sea)water splitting using semiconductors is a promising means of producing renewable hydrogen without environmental pollutions. [1] The n-type perovskite oxynitrides $AB(O,N)_3$ (A=La, Ca, Sr, or Ba; B=Ti, Nb, or Ta) are highly responsive to visible-light wavelengths up to or even above 600 nm (E_g=1.7~2.1 eV), thus leading to solar-to-hydrogen conversion efficiency of 10% for (sea)water splitting. [2] Band edge potentials of the oxynitrides straddle water redox potentials, which they drive overall water splitting with no applied bias. However, the water splitting activity over the oxynitrides remains limited. Herein we report recent advances in the bulk and surface engineering and the corresponding photoactivities of $AB(O,N)_3$ for efficient water splitting. The alternative oxidation of the oxynitrides in seawater will be also highlighted in a presentation.

[1] G. Liu et al., Energy Environ. Sci., 2016, 9, 1327.
[2] J. Seo et al., Angew. Chem. Int. Ed., 2018, 57, 2.

SS3-2 | 그린수소 생산을 위한 유기반도체 기반의 광전극 구현

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Harnessing solar energy to directly split water into hydrogen (H_2) and oxygen (O_2) has been recognized as a leading strategy for reducing our dependence on fossil fuels since hydrogen can be converted into electricity using a fuel cell or transformed into useful chemical feedstocks. However, a significant challenge remains in identifying ideal light-harvesting semiconductors that meet both performance and cost criteria required for large-scale implementation. Organic photoelectrodes in which pi-conjugated organic semiconductors (OSs) are combined with co-catalysts have recently garnered significant recognition as alternative photoelectrodes for solar water reduction (yielding H_2) and oxidation (yielding O_2), considering unique properties of OSs such as their precisely tunable light-harvesting capability and solution-processability at low temperatures. Nevertheless, organic photoelectrodes for solar water splitting have shown disappointing conversion efficiency and instability. In this talk, I will present an in-depth study that uses sacrificial oxidation/reduction agents to unveil critical parameters determining the performance and operational stability of organic photoelectrodes. By leveraging the insights from the in-depth study, the optimized organic photocathode and photoanode, where semiconducting polymer layers are coupled with hydrogen and oxygen evolution catalysts respectively, are demonstrated with a new benchmark of organic photoelectrodes for solar water splitting.

SS3-3 | 유기 광촉매의 전하 동역학에 대한 연구

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Photocatalytic hydrogen generation is an emerging method for achieving sustainable energy production and addressing energy deficiencies and environmental issues. In comparison to their inorganic count part, organic semiconductor-based photocatalysts offer several advantages, including tunable structural and optoelectronic properties, low cost, and stability. To achieve superior performance from these organic photocatalysts, it is crucial to comprehend the relationship between molecular design and charge carrier dynamics within photocatalytic processes. Here we address the charge carrier dynamics in organic photocatalytic nanoparticles for hydrogen evolution. We investigate the mechanism behind the dependence of photocatalytic activity on Pd content for a linear polymer, and place particular emphasis on the effect of Pd on the excited state of the polymer and on the accumulation of long-lived charges during catalysis. We will address the novel concept of the organic nanoparticles for visible light absorption and efficient charge separation.

SS3-4 | 리그노셀룰로오스계 바이오매스를 이용한 태양광 수소 및 유용화학물질 생산

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The growing demand for sustainable energy sources and green chemical production has led to increased research in harnessing solar energy for the production of hydrogen and value-added chemicals. Lignocellulosic biomass is a renewable and abundant carbon resource and offers a promising avenue for such endeavors. This presentation explores the innovative integration of solar technologies with lignocellulosic biomass conversion processes to achieve efficient hydrogen generation and the synthesis of value-added chemicals. Various photochemical processes will be introduced, highlighting their potential to utilize solar radiation for biomass

decomposition, hydrogen extraction, and the creation of valuable chemical compounds. As solar technologies continue to advance and lignocellulosic biomass processing becomes more sophisticated, the synergy between these fields holds great promise for a more sustainable and carbon-neutral future.
References: 1. H. Oh et al., ACS Catal. 2020, 10, 2060. 2. Y. Choi et al., Nat. Commun. 2022, 13, 5709. 3. S.-J. Yim et al. Adv. Sci. 2022, 9, 2204170. 4. Y. Choi et al., Adv. Mater. 2023, 35, 2301576.

SS3-5 | 태양광 연료생산을 위한 촉매 표면 제어 기술

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(Photo)electrochemical energy conversion provides an exciting new route for sustainable fuels and value added chemicals production with reducing energy cost and environmental concerns like green-house gas emissions. Especially, interfacial engineering is one of effective topics to develop photo-electro-catalytic applications such green H_2 production, N_2-NH_3 conversion, CO_2 reduction, and so on. For example, interfacial engineering to form efficient triple-phase-boundary (catalyst-water-N_2) can dominantly determine activity of (photo)electrochemical N_2 reduction reaction (P-ENRR). Moreover, final products, produced by (photo)electrochemical CO_2 reduction, can be even altered by local environments near catalysts, adjusted by interfacial engineering. In this talk, we will mainly introduce multiple strategies to engineer catalyst interface and how they affect to improve photo- electro-catalytic reactions.

SS3-6 | 광-전기화학적 이산화탄소 환원 반응용 전극 미세환경 제어

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Conversion of carbon dioxide (CO_2) with water (H_2O) using electricity from renewable sources (especially, solar irradiation) offers the potential for a sustainable production of chemicals and fuels. As a mean to this end, photo- and electrochemical CO_2 reduction (CO_2R) has great attention recently, but it suffers competing evolution of hydrogen (H_2) as a byproduct by leveraging H_2O as a clean and abundant source of protons. Thus, it is crucial to minimize H_2 evolution to maximize the utilization of electrical power for CO_2R. Another goal is to selectively produce valuable multicarbon products (C_{2+} products) like C_2H_4, C_2H_5OH, and C_3H_7OH, which are more economically valuable than single-carbon products (C_1 products) such as HCOOH, CO, and CH_4. Copper (Cu)-based materials stand out among various CO_2R catalysts due to their ability to produce C_{2+} products with notable activity and selectivity which are strong function of microenvironments near cathode. In this reagrd, This talk will introduce the impact of these microenvironments near Cu catalysts and explores how these knowledges can be effectively applied to design a photocathode for the photo-electrochemical reduction of CO_2 to produce C_{2+} products.