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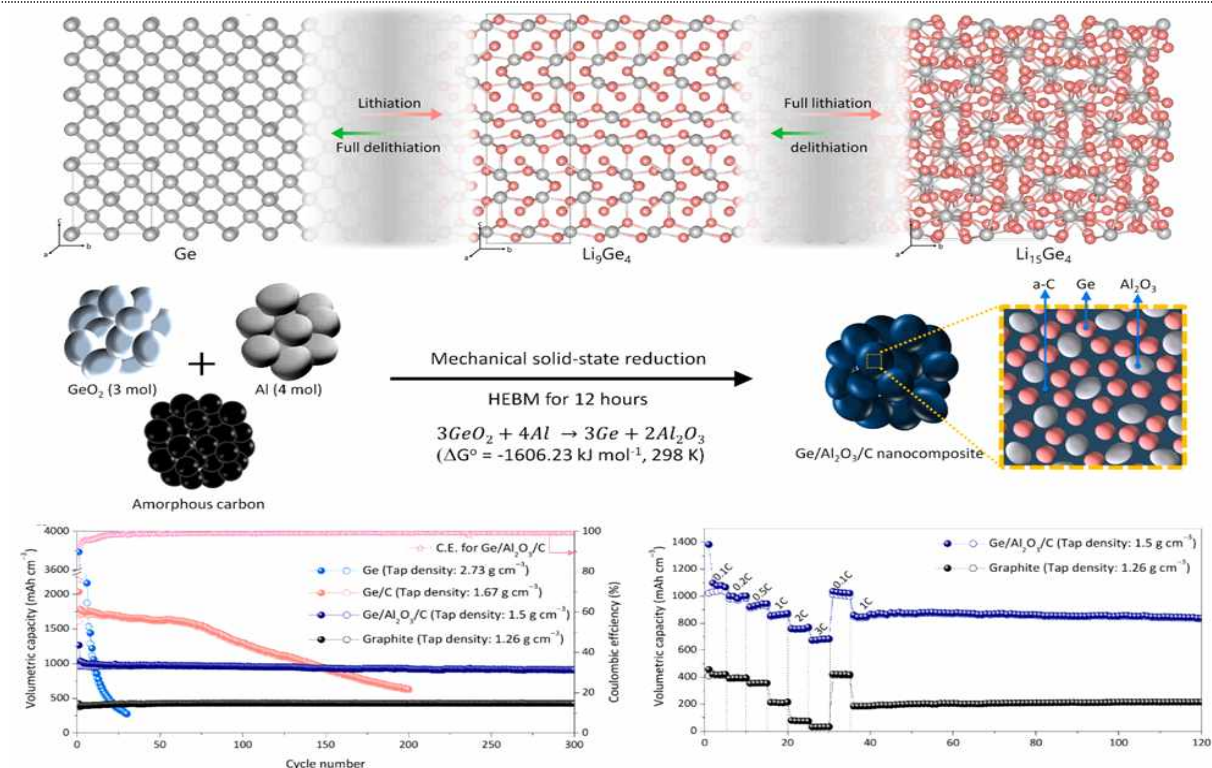
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Li reaction pathways in Ge and high-performance Ge nanocomposite anodes for Li-ion batteries

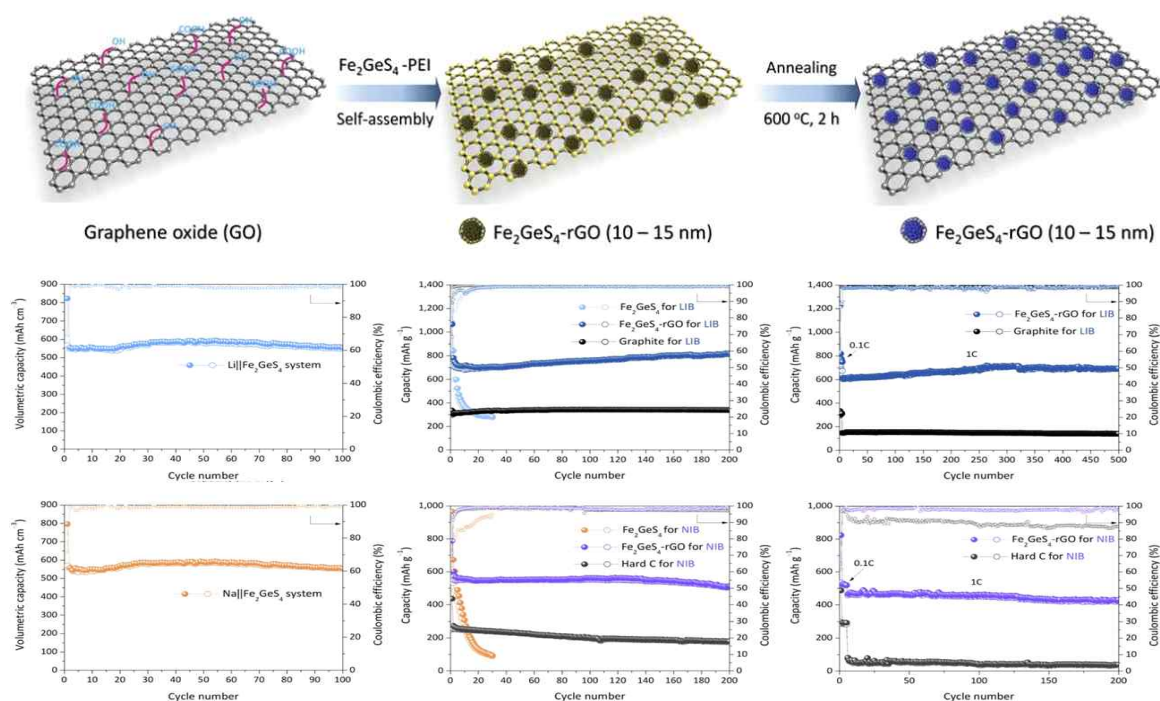
Dong-Hun Lee, Do-Hyeon Kim, Heechul Jung*, Cheol-Min Park*



Ge is a highly researched anode material for Li-ion batteries (LIBs) owing to its high theoretical Li storage capacity and higher electrical conductivity compared to that of Si. However, Li reaction pathways in Ge have not been definitively established due to the formation of various and complicated Li-Ge alloy phases during lithiation/delithiation. Evaluation of the Li storage characteristics of bulk and nanocrystalline Ge demonstrated that nanocrystalline Ge showed higher Li reversibility than bulk Ge. Various cutting-edge ex situ techniques were used to analyze nanocrystalline Ge, and the Li reaction pathways in Ge were thoroughly demonstrated. To enhance the electrochemical Li storage characteristics of Ge, a Ge-based nanocomposite, Ge/Al₂O₃/C, was synthesized via simple one-pot mechanical solid-state reduction using GeO₂, Al, and C. Ge/Al₂O₃/C exhibited very stable cyclic behavior at a current density of 100 mA g⁻¹ over 300 cycles (capacity retention after 300 cycles: ~95 %). Moreover, Ge/Al₂O₃/C exhibited excellent rate capability with high reversible capacity and stable cyclic behavior at a high 1C-rate. The superior electrochemical performance of Ge/Al₂O₃/C was attributed to the nanoscale dimensions of Li-active nanocrystalline Ge (~10 nm) and Li-inactive Al₂O₃ (~12 nm) embedded uniformly in the amorphous carbon matrices. The size of nanocrystalline Ge in nanocomposite was consistently maintained during repeated cycles owing to the anti-agglomeration effect of the uniformly distributed Li-inactive Al₂O₃ and amorphous carbon matrices. We anticipate that the electrochemical Li reaction pathways in Ge and the resulting high-performance nanocomposite anodes will be highly useful in investigating high-performance Ge-based anodes for LIBs.

Versatile Fe_2GeS_4 for Li/Na- Fe_2GeS_4 battery cathodes and Li/Na-ion battery anode

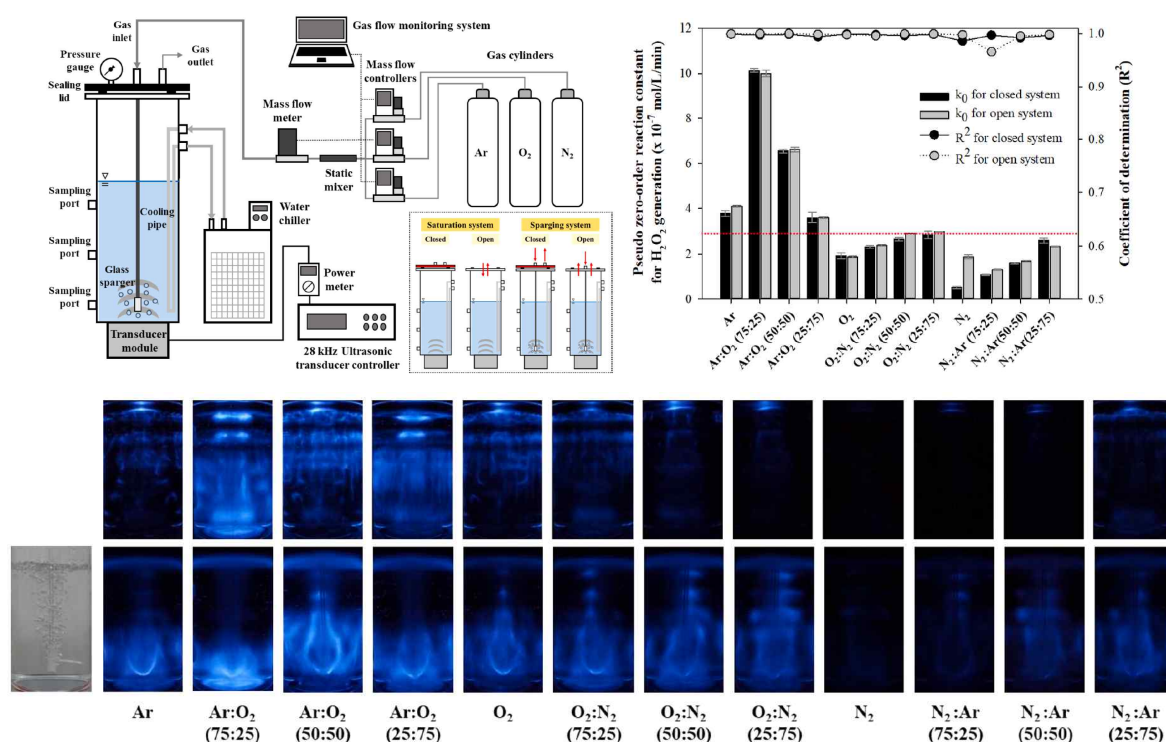
Vinoth Ganesan, Ki-Hun Nam, Jae-Hun Kim*, Cheol-Min Park*



Metal chalcogenides are promising candidates for various energy storage applications. Herein, a ternary Fe_2GeS_4 compound was synthesized using a simple solid-state method and applied as versatile electrodes for rechargeable Li/Na- Fe_2GeS_4 battery cathodes and Li/Na-ion battery anodes. In addition, distinctive Li and Na reaction pathways for Fe_2GeS_4 consisting of insertion and conversion reactions have been demonstrated. For its application as rechargeable Li/Na- Fe_2GeS_4 battery cathodes, $\text{Li}||\text{Fe}_2\text{GeS}_4$ and $\text{Na}||\text{Fe}_2\text{GeS}_4$ battery systems were electrochemically evaluated by controlling the cut-off voltages within the insertion reaction and they showed high electrochemical performance with high reversible volumetric capacities and cyclability with appropriate cell potentials ($\text{Li}||\text{Fe}_2\text{GeS}_4$: 550 mA h cm⁻³ over 100 cycles with 1.6 V; $\text{Na}||\text{Fe}_2\text{GeS}_4$: 555 mA h cm⁻³ over 100 cycles with 1.2 V). In addition, for using Fe_2GeS_4 as an anode for Li-ion batteries (LIBs) and Na-ion batteries (NIBs), graphene-wrapped Fe_2GeS_4 nanocomposite (Fe_2GeS_4 -rGO) comprising Fe_2GeS_4 nanocrystallites (10–15 nm) embedded on reduced graphene oxide (rGO) was synthesized through a simple two-step synthetic method to improve the electronic/ionic conductivity, structural stability, and mechanical strain relaxation. The electrochemical test results indicated that the Fe_2GeS_4 -rGO exhibited high initial reversible gravimetric capacities (730 mA h g⁻¹ for LIB, 563 mA h g⁻¹ for NIB), high rate capability (520 mA h g⁻¹ at 3C for LIB, 470 mA h g⁻¹ at 2C for NIB), and an excellent cycling performance at a high 1C rate (capacity retention: 100% over 500 cycles for LIBs, 93% over 200 cycles for NIBs). Therefore, we believe that Fe_2GeS_4 is a highly applicable compound material for various battery systems.

Effects of gas saturation and sparging on sonochemical oxidation activity in open and closed systems, Part I: H_2O_2 generation

Youngyu Son*, Jieun Seo



Cavitation/sonochemical activity can be significantly enhanced or reduced depending on the gases dissolved in the liquid. Although many researchers have suggested the order of importance of dissolved gas conditions that affect the degree of sonoluminescence (SL), sonochemiluminescence (SCL), and compound degradation, the most suitable gas condition for sonochemical oxidation reactions is currently unknown. In this study (Part I), the effects of gas saturation and sparging on the generation of H_2O_2 were investigated in a 28 kHz sonoreactor system. Four gas modes, saturation/closed, saturation/open, sparging/closed, and sparging/open, were applied to Ar, O₂, N₂, and binary gas mixtures. The change in dissolved oxygen (DO) concentration during ultrasonic irradiation was measured and was used as an indicator of whether the gaseous exchange between liquid and air altered the gas content of the liquid. Considerable difference in the DO concentration was observed for the gas saturation/open mode, ranging from -11.5 mg/L (O₂ 100 %) to +4.3 mg/L (N₂ 100 %), while no significant difference was observed in the other gas modes. The change in the gas content significantly reduced the linearity for H_2O_2 generation, which followed pseudo-zero-order kinetics, and either positively or negatively affected H_2O_2 generation. Ar:O₂ (75:25) and Ar:O₂ (50:50) resulted in the highest and second-highest H_2O_2 generation for both gas saturation and sparging, respectively. In addition, gas sparging resulted in much higher H_2O_2 generation for all gas conditions compared to gas saturation; this was because of the significant change in the cavitation active zone and concentrated ultrasonic energy, which formed a bulb-shaped active zone, especially for the Ar/O₂ mixtures adjacent to the transducer at the bottom. The sparging flow rate and position also significantly affected H_2O_2 generation; the highest H_2O_2 generation was obtained when the sparger was placed at the bottom adjacent to the transducer, with a flow rate of 3 L/min. In Part II, the generation of nitrogen oxides, including nitrite (NO₂⁻) and nitrate (NO₃⁻), was investigated using the same ultrasonic system with three gas modes: saturation/open, saturation/closed, and sparging/closed.

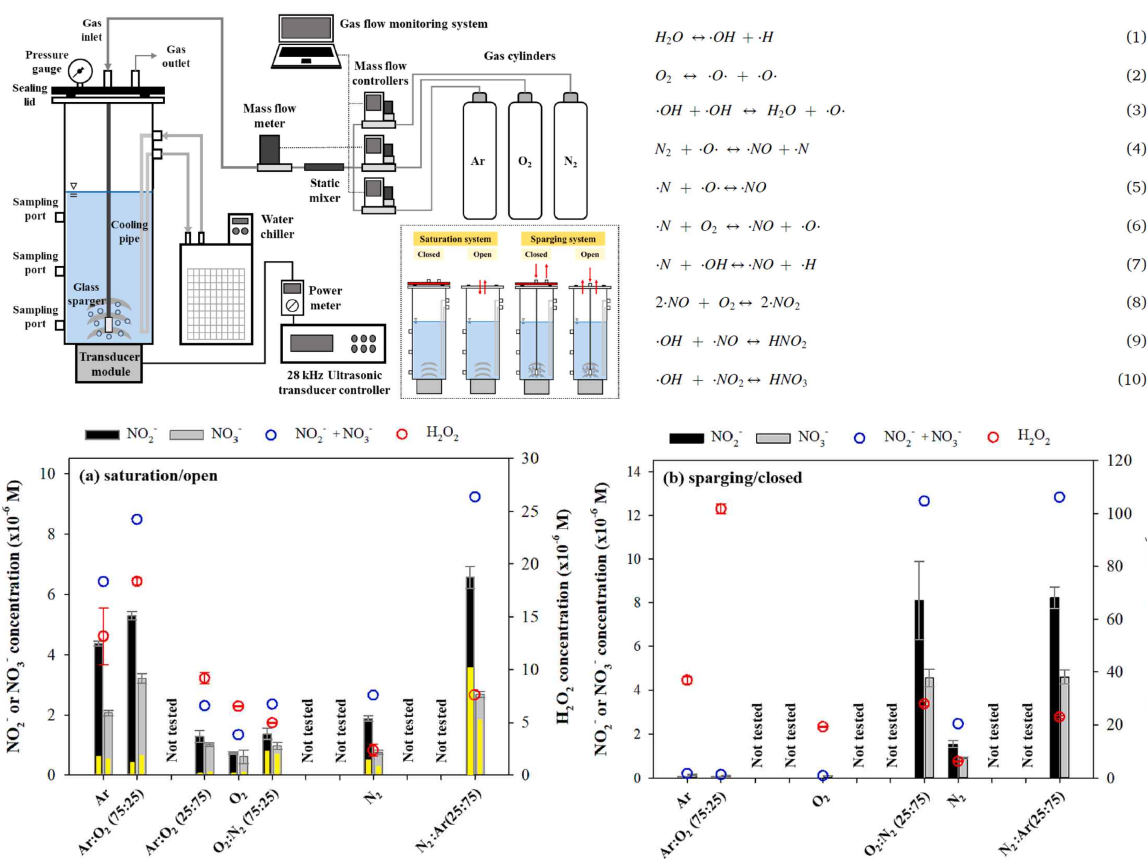
환경에너지

Ultrasonics Sonochemistry

Volume 92, January 2023, 106250 (Impact Factor : 9.336)

Effects of gas saturation and sparging on sonochemical oxidation activity in open and closed systems, part II: NO₂⁻/NO₃⁻ generation and a brief critical review

Youngyu Son*, Jongbok Choi



The sonochemical generation of NO₂⁻ and NO₃⁻ is considered to be one of the reasons for the low sonochemical oxidation activity in the presence of N₂ in the liquid phase. In this study, the generation characteristics of NO₂⁻ and NO₃⁻ were investigated using the same 28 kHz sonoreactor and the 12 gas conditions used in Part I of this study. Three gas modes, saturation/closed, saturation/open, and sparging/closed, were applied. N₂:Ar (25:75), N₂:Ar (50:50), and O₂:N₂ (25:75) in the saturation/closed mode generated the three highest values of NO₂⁻ and NO₃⁻. Ar and O₂ were vital for generating relatively large concentrations of NO₂⁻ and NO₃⁻. The absorption of N₂ from the air resulted in high generation of NO₂⁻ and NO₃⁻ for Ar 100 % and Ar/O₂ mixtures under the saturation/ open mode. In addition, gas sparging enhanced the generation of NO₂⁻ and NO₃⁻ for N₂:Ar (25:75), O₂:N₂ (25:75), and N₂ significantly because of the change in the sonochemically active zone and the increase in the mixing intensity in the liquid phase, as discussed in Part I. The ratio of NO₃⁻ to NO₂⁻ was calculated using their final concentrations, and a ratio higher than 1 was obtained for the condition of Ar 100 %, Ar/O₂ mixtures, and O₂ 100 %, wherein a relatively high oxidation activity was detected. From a summary of the results and findings of previous studies, it was revealed that the observations of NO₂⁻ + NO₃⁻ could be more appropriate for investigating the NO₂⁻ and NO₃⁻ generation characteristics. In addition, H₂O₂/NO₂⁻/NO₃⁻ related activity rather than H₂O₂ activity was suggested to quantify the OH radical activity more appropriately in the presence of N₂.

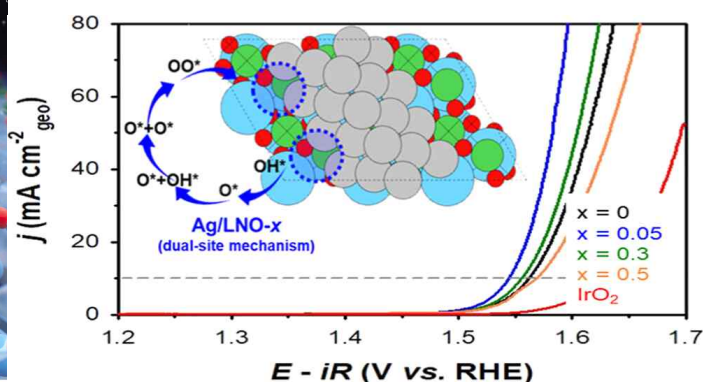
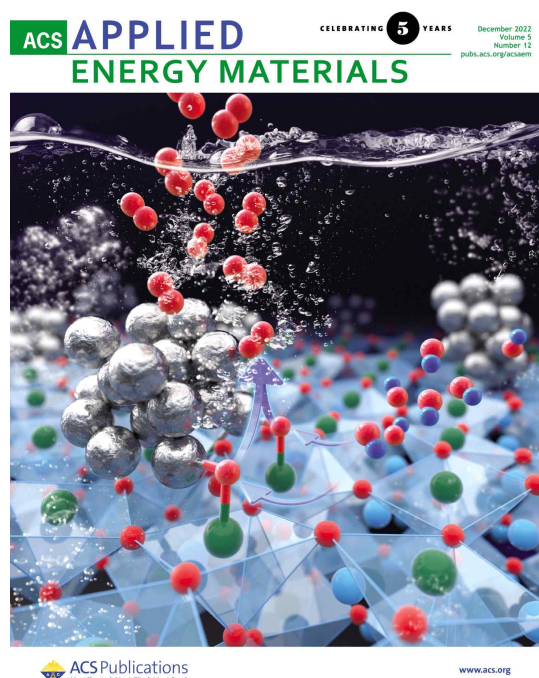
수소에너지

ACS Applied Energy Materials

Volume 5, December 2022, p14658 (Impact Factor : 6.959)

Direct O-O Coupling Promoted the Oxygen Evolution Reaction by Dual Active Sites from Ag/LaNiO₃ Interfaces

Seonggyu Lee, M. R. Ashwin Kishore, Dongkyu Kim, Hari Kang, Jinyoung Chun, Lee Seul Oh, Jong Hyeok Park, Hyung Ju Kim, Jong Suk Yoo*, Eunho Lim*



The development of highly active oxygen evolution reaction (OER) electrocatalysts is one of the most important issues for advanced water electrolysis technology with high energy efficiency. However, according to the conventional adsorbate evolution mechanism (AEM), the OER activity is theoretically limited with high overpotential by the scaling relationship in binding energies of the reaction intermediates. We propose an attractive strategy to promote OER activity by direct O-O coupling at the interfacial active sites for Ag (x) nanoparticles decorated on La_{1-x}NiO₃ perovskite electrocatalysts (Ag/LNO-x). The overpotential of the Ag/LNO-0.05 was 315 mV at a current density of 10 mA cm⁻²_{geo}, which was much lower than that of other Ag/LNO-x (x = 0, 0.3, and 0.5) and commercial iridium oxide (IrO₂, 398 mV) electrocatalysts. The theoretical calculation revealed that the improved OER electrocatalytic activity of Ag/LNO-x originated from a change in the reaction mechanism at the interfacial active sites. At the interface, oxygen evolution via the dual-site mechanism with direct O-O coupling becomes more favorable than that via the conventional AEM. Finally, due to the formation of the interfacial active sites, the synthesized Ag/LNO-0.05 electrocatalyst showed significantly enhanced OER activity, which was 20 times higher mass activity before and 74 times after an accelerated durability test than that of the IrO₂ electrocatalyst.

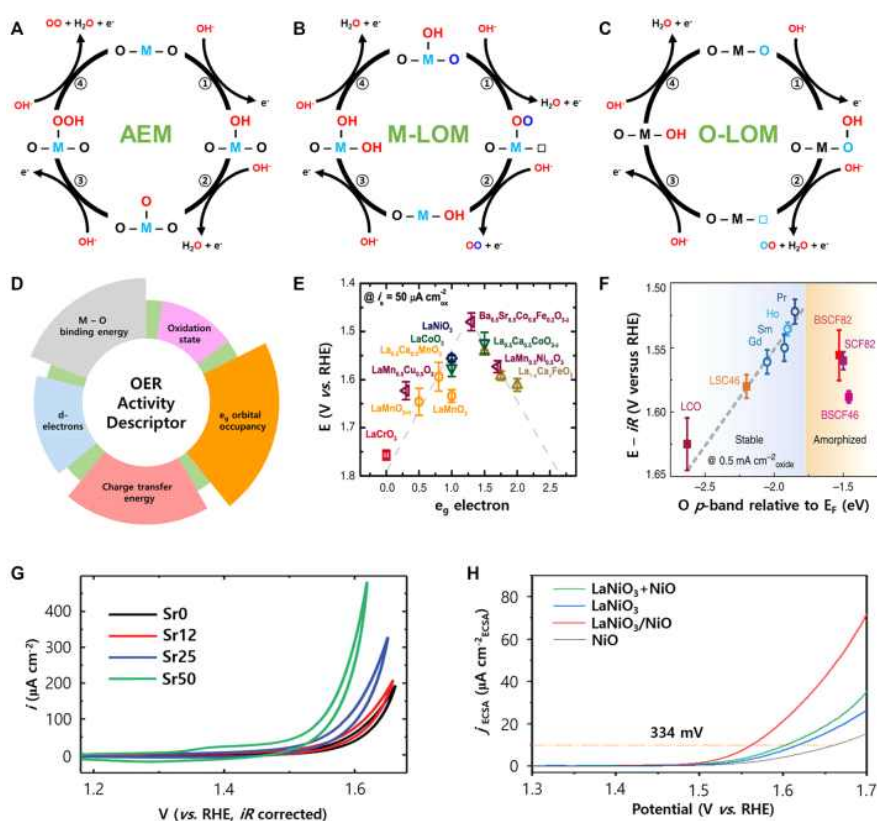
수소에너지

Frontiers in Chemistry

Volume 10, October 2022, p1024865 (Impact Factor : 5.545)

Perovskite-based electrocatalysts for oxygen evolution reaction
in alkaline media: A mini review

Dongkyu Kim, Lee Seul Oh, Jong Hyeok Park, Hyung Ju Kim, Seonggyu Lee*, Eunho Lim*



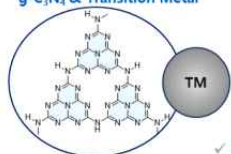
Water electrolysis is one of the attractive technologies for producing clean and sustainable hydrogen fuels with high purity. Among the various kinds of water electrolysis systems, anion exchange membrane water electrolysis has received much attention by combining the advantages of alkaline water electrolysis and proton exchange membrane water electrolysis. However, the sluggish kinetics of the oxygen evolution reaction, which is based on multiple and complex reaction mechanisms, is regarded as a major obstacle for the development of high-efficiency water electrolysis. Therefore, the development of high-performance oxygen evolution reaction electrocatalysts is a prerequisite for the commercialization and wide application of water electrolysis systems. This mini review highlights the current progress of representative oxygen evolution reaction electrocatalysts that are based on a perovskite structure in alkaline media. We first summarize the research status of various kinds of perovskite-based oxygen evolution reaction electrocatalysts, reaction mechanisms and activity descriptors. Finally, the challenges facing the development of perovskite-based oxygen evolution reaction electrocatalysts and a perspective on their future are discussed.

태양에너지

Molecular Catalysis

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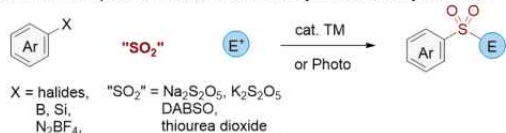
Recyclable and dual active catalyst of copper nanocluster-bound graphitic carbon nitride for the photo-induced synthesis of arylsulfones

Jinseok Lee¹, Seunghwan An¹, Mihee Jang, Hyun Min Jung*, Sunwoo Lee*a) Application of g-C₃N₄-metal oxide-based Nanocompositesg-C₃N₄ & Transition Metal

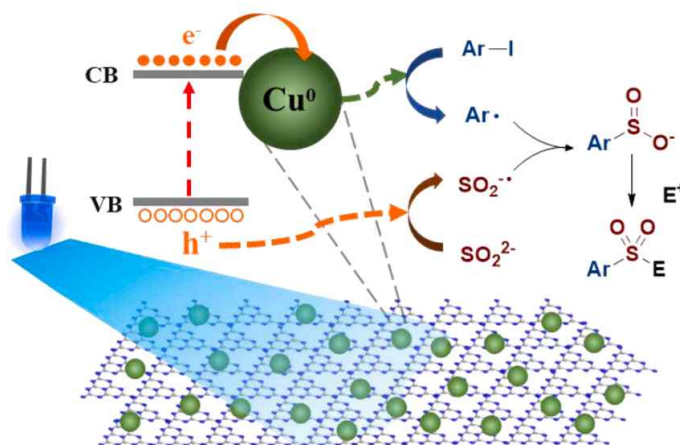
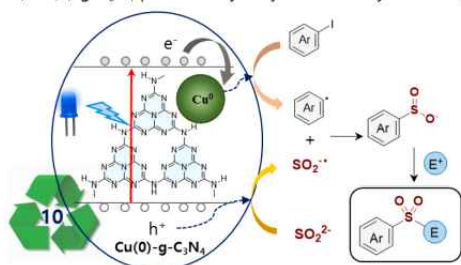
- Photocatalyst
 - H₂ or O₂ evolution reactions
 - CO₂ reduction
 - photodegradation
 - organic synthesis
- Sensors

✓ No dual catalytic activity was reported

b) Three component reactions for the synthesis of arylsulfones



- ✓ All homogeneous catalytic system
- ✓ No recyclable catalyst was reported

c) Cu(0)-g-C₃N₄ photo catalyst: Synthesis of arylsulfones (This work)

A photocatalytic system of Cu(0) nanocluster-bound graphitic carbon nitride (Cu(0)-g-C₃N₄) was developed for three-component arylsulfonylation reactions. The Cu(0)-g-C₃N₄ nanocomposite has a structure in which 2-5 nm metallic Cu nanoclusters are anchored on the surface of g-C₃N₄ nanosheets. The Cu(0) clusters were synthesized by reducing Cu²⁺ ions with ascorbic acid in the presence of g-C₃N₄ nanosheets. Cu(0)-g-C₃N₄ was designed to exhibit dual catalytic activity involving the transfer of photo-induced electrons from g-C₃N₄ to Cu(0) for the reduction of arylhalides, while the holes in g-C₃N₄ oxidize the sulfur dioxide anion. The structure of the catalyst was confirmed by electron microscopy, X-ray diffraction, and X-ray photoelectron spectroscopy. The well-defined, air-stable Cu(0)-g-C₃N₄ catalyst effectively promotes the sulfonylation of aryl iodides, thiourea dioxide, and electrophiles to afford the corresponding arylsulfonyl compounds in moderate to good yields. The reusability of the catalyst was also evaluated, and it could be reused up to ten times in arylsulfonylation without the loss of its activity.