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Editorial: Catalysts for Clean Energy Conversion and Storage

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Editorial on the Research Topic

Catalysts for Clean Energy Conversion and Storage

Clean energy conversion and storage technologies, such as fuel cells, metal-air batteries and water-splitting, are currently under intensive investigation for their high efficiency, promising large-scale applications and virtually no pollution, or greenhouse gas emissions. However, noble metal catalysts (e.g., platinum, Pt, and its derivatives) are usually used to promote key chemical reactions, such as oxygen reduction reaction (ORR), oxygen evolution reaction (OER), and hydrogen evolution reaction (HER), occurring in the energy devices. The limited resources and high cost of the Pt catalysts have hindered the technologies for commercial applications. Therefore, it is necessary to develop low-cost, highly-efficient electrocatalysts. This Research Topic is focused on this critical issue in the clean energy technologies.

This Research Topic has collected seven excellent original research papers covering several aspects of the electrocatalysts for the clean energy conversion and storage. Various materials, including non-precious metals, metal oxides, carbon nanomaterials, covalent organic frameworks, and even single-atom catalysts, have been developed with potential to replace commercial noble metal catalysts. Song et al. synthesized an efficient bi-functional electrocatalyst of Ni-Co mixed metal oxides incorporated with cobalt/nitrogen-doped carbon with hierarchical hollow nanostructure (H-Co/N-C@$NiCo_2O_4$). Their catalyst exhibits superior electrocatalytic activity and long-time durability for both ORR and OER for rechargeable Zn-air batteries. Xiao et al. developed a 3D highly ordered porous MnO_2@Ni-pc nanocomposite that significantly enhance ORR performance of MnO_2 with high onset potential and large limiting current density. Xu et al. reported a general strategy for the fabrication of bi-metal Ni and Fe single-atom catalysts loaded on graphene to boost the OER activity.

Methods and approaches have also been developed to reduce the use of noble metals while improving their activities and stability. Luo et al., an elegant and controllable atomic layer deposition (ALD) technique was used to synthesize cost-efficient Pt-based catalysts, immobilized on functionalized Vulcan Carbon from hydrothermal treatment of Ru precursor and ethylene glycol solution, which exhibits remarkably boosted HER activity and stability. Cui et al. reported a porous aromatic framework synthesized *via* ionothermal reaction, which shows excellent activity in hydrogen generation from hydrolysis of ammonia borane and good cyclic performance.

Additionally, insights into the catalytic mechanism of metal-free carbon nanomaterials have been gained via the first-principles calculations. Two-dimensional covalent organic polymers (COPs) are promising as efficient catalysts for ORR. Li et al. designed four COP models (COP-Bn, $n = 3, 4, 5, 6$) and used the density function theory (DFT) methods to study their

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ORR performance. Heteroatom-doped carbon nanomaterials have been demonstrated to be an efficient electrocatalyst for ORR but its activity is relatively low in acidic environments. Ma et al. found that protonation and adsorption of acid radical ions are two major factors that result in the inferior catalytic performance of the doped graphene in acidic environments. Their results would provide a direction and hints to rationally design high performance catalysts.

AUTHOR CONTRIBUTIONS

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