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Editorial

Synthesis and Applications of Bimetallic-Derived Catalysts on Semiconductor Materials for Photoelectrocatalytic Processes

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Photoelectrocatalysis takes advantage of electrocatalytic and photocatalytic processes. By applying biased potential on a photoelectrode in which a catalyst is supported, this technology provides an effective solution to (i) overcome kinetic barriers in traditional electrochemical conversion by catalytic materials with the assistance of solar power and (ii) inhibit the recombination of the photogenerated electron-hole pairs in typical photocatalytic systems [1]. Significant advances in materials science and nanomaterials have vastly increased the efficiency, versatility, and applicability of photoelectrocatalytic devices in different fields such as hydrogen generation [2,3], air and water depollution [2,4], CO_2 recycling [5], and electricity generation [6].

Recently, new composite photoelectrodes, based on *bimetallic*-derived catalysts, have started to appear. They exhibit superior photoelectrocatalytic activity (higher photocurrent densities and reduced onset potentials), selectivity, and stability compared to their monometallic counterparts; this was achieved through the original engineering of their structural, architectural, and compositional features. Different bimetallic catalyst configurations (molecular, supramolecular, plasmonic NPs, metal oxides, MOFS) are currently being explored. Some examples are described in the following.

Wang et al. recently demonstrated that bimetallic $NiMoO_4$ nanosheets deposited onto TiO_2/g-CN heterojunctions form a stable TiO_2/g-CN/$NiMoO_4$ 3D photoelectrocatalyst was able to provide a photocurrent density for water oxidation as high as 1.8 mA/cm^2 under 1 sun at 1.23 V versus RHE (two times higher than pristine TiO_2) with a faradaic efficiency, *FE*, of 93.6% for 12 h [7]. The improved performance was ascribed to the original hybrid assembly, with an expansion of the photoresponse to a visible range by the g-CN/TiO_2 heterojunction alongside the highly catalytic surface provided by $NiMoO_4$ for OER. Another example of bimetallic TiO_2 functionalization has been given by Chen et al. for application in environmental remediation [8]. They proposed Au-Pd/TiO_2 nanobelts synthesized by bimetallic Au-Pd electrodeposition as a super-reusable photoelectrocatalyst for the degradation of the antibiotic levofloxacin (LEV) in an aqueous solution (demonstrating enhanced visible light absorption, low recombination, and a photoelectrochemical degradation efficiency of 95%).

Molecular catalysts based on transition metal complexes are well-known for their selectivity. Kamata et al. recently presented a novel route to synthesize a bimetallic supramolecular photoelectrocatalysist for CO_2-to-CO reduction: poly-RuRe/NiO [9]. The poly-RuRe/NiO showed increased activity in an aqueous solution and improved stability vs. simple RuRe/NiO (the total *FE* of 85% against 57%, respectively).

Finally, plasmonic metal nanostructures have gained attention in the quest for efficient solar-to-fuel energy conversion. Deng et al. showed that the strongly coupled Cu-Pt core–shell nanoparticle (fabricated by combining top-down lithography and solution-based chemistry) deposited on an ITO possesses exceptional photoelectrocatalytic activity for HER (the current density of c.a. 2 mA/cm^2 under the white light of 450 mW/cm^2 at -0.2 V vs. RHE), with a two-fold activity enhancement of the surface lattice resonances compared to localized surface plasmons [10].

This *Special Issue* aims to cover recent advances in developing bimetallic-derived catalysts on semiconductor materials and their applications in photoelectrocatalytic processes. Synthesis and assembling processes and insights on electronic, geometrical, and compositional effects in the photoresponse and photo-electrocatalytic cell conception and implementation are all encouraged—but not restrictive—topics. This Special Issue aims to bring together expertise, concepts, and ideas in the field of bimetallic catalyst-based photoelectrodes to strengthen the current state of knowledge, highlight the latest advances, and bring forth anticipated applications relating to energy transition and environmental sustainability. With their remarkable tunning possibilities, bimetallic-derived catalysts on semiconductor materials will be part of the next era of photoelectrocatalysts for the energy transition.

Conflicts of Interest: The authors declare no conflict of interest.

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