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Editorial

Editorial: Special Issue on Advanced Functional Materials for Photo/Electro-Catalysts for Environmental and Energy Applications

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In the last three decades, it has become clearly evident that a sustainable approach to environmental issues and non-fossil energy production is impossible without functional materials. Keeping this in mind, a Special Issue devoted to advanced functional materials for photo(electro)catalytic environmental, energy, and CO_2 reduction into solar fuels addresses water, atmospheric pollution, and energy issues. In order to attain sustainable development goals (SDG6) relating to environmental well-being, further study is being conducted on the development of innovative materials. In this Special Issue, durable innovative inorganic materials, organic materials, organic/inorganic hybrids materials, and advanced functional materials for sustainable water, environmental remediation, solar utilization, and solar fuel conversion are discussed. Reporting on additional electrocatalytic water splitting, CO_2 reduction, and fuels, as well as photo(electro)catalytic solar fuels, was also a priority.

Many materials are used in research regarding CO_2 reduction, among which Cu_2O is a promising material [1]. In this Special Issue, a review discusses why Cu_2O is a promising catalyst in CO_2 reduction based on its structure, interfacial charge, surface area, quantum efficiency, and functional groups through photochemical and electrochemical routes. Also, various Cu_2O synthesis routes are reported on in detail, which enable shapes like zero-, one-, two-, and three-dimensional structures to be achieved for specific or enhanced applications as photocatalysts/electrocatalysts. This article outlines recent developments and breakthroughs in the electrochemical or photochemical conversion of CO_2 to usable chemical fuels.

Conghui et al. (2022) [2] provide a comprehensive overview of perovskite catalysts for hydrogen production via water splitting. Perovskite oxides have emerged as promising candidates for efficient water splitting electrocatalysts due to their low cost, high electrochemical stability, and compositional and structural flexibility that permits the achievement of high intrinsic electrocatalytic activity, despite the fact that many materials are currently in use. In this article, the authors summarize the current research advancements in the design, development, and application of perovskite oxides for electrocatalytic water splitting via doping/substitution, surface modification, morphology, and defect engineering. In addition, as a future aspect, the primary challenges and prospects for the further development of more efficient electrocatalysts based on perovskite oxides are described in detail. Hefeng et al. (2023) [3] report on semiconductor materials for solar water splitting with a modest bandgap (2.1 eV). Under a small-bandgap semiconductor, various materials such as hematite; Cu_2O; Cu-based composites; and selenide-based, phosphate-based, iodide-based, and silicon-based materials serve as semiconductors for fundamental, mechanical purposes.

Ambati et al. (2023) [4] report on a graphene-incorporated cupric oxide (CuO@Gra-COOH) material for use in a hydrogen evaluation reaction (HER). This study reports a low-cost, scalable solution-based approach for the fabrication and design of CuO:Gra-COOH photocathodes and shows that graphene incorporates nanoparticles into the CuO film, which improves the electrical and optical properties of the film. Additionally, it is observed that the graphene functional group plays a significant role in making more effective and stable photoelectrodes due to its electron-accepting tendency. According to the DFT calculations between different complexes of graphene with CuO, CuO@Gra-COOH shows the finest and most stable complex due to its high energy gap of 0.78 and charge distribution of $-0.81|e|$. The presence of an ultra-thin CuO:Gra-COOH charge-transport layer shows ~9.3 µmol H_2 evolution.

Raji et al. (2023) [5] report on the preparation of bio-waste-derived heteroatom carbon as a material for use in a hydrogen evaluation reaction (HER). Heteroatoms such as oxygen, nitrogen, and sulfur species are uniformly distributed by the proposed synthesis route with a surface area of 565 m^2/g. The porous structure with interconnected channels supports the transportation/penetration of electrolytes for the rapid release of the HER process. The electro-catalytic activity through the Tafel slope of 75 mV/dec shows that the prepared material has excellent long-lasting durability.

Karna et al. (2021) [6] report on a sulphate nickel-impregnated silica catalyst material for application in ethanol to fuel conversion. It is proposed that this material can outperform metal-based catalysts for ethanol to fuel conversion. The highest yield from the ethanol dehydration reaction is obtained using the sulphate-impregnated silica calcined at 400 °C and the catalyst at a temperature of 225 °C at 9.54%. The activity and selectivity of the 3%/Ni-silica catalyst show the highest conversion of liquid and DEE conversion at 84.03 and 24.01%, respectively.

Suguna et al. (2022) [7] report on the green synthesis and application of carbon-dot-decorated Ag (CDs@AgNP) for catalytic dye degradation. The catalytic performance of the CDs@AgNP composite is studied in terms of the reductive degradation of methylene blue and methyl orange using synthetic solution. The reductive catalytic activities of the CDs@AgNP composite in the presence of SB against the degradation of MB and MO under ambient conditions are measured as 99.5 and 99.0% within 15 and 20 min, respectively.

Shelly et al. (2023) [8] report on a BiVO4/Sb2S3 nanocomposite material for the photocatalytic oxidation of tetracycline. Different process parameters such as the concentration of the photocatalyst, the pH effect of the detrimental pollutant, kinetic studies, the effect of the light source, a scavenger study, and a reusability experiment are optimized for the prepared material. The material synthesis has a ionic ratio of 1:3 and 3:1, and the composite exhibits the highest photocatalytic decomposition efficacies among the synthesized photocatalysts, which are 88.7% and 89.6%, respectively.

Sulakshana et al. (2023) [9] report on the synthesis of Fe_2O_3 from a natural hematite ore/C_3N_4 Z-scheme photocatalyst for ofloxacin removal. Among the varied compositional preparation methods, 5% of Fe_2O_3 on C_3N_4 shows 7.5 times higher photocatalytic activity. The catalyst is quite stable, even after five repeated cycles of photodegradation. The photoluminescence analysis and electrochemical measurements confirm the efficient separation and transfer of the photogenerated charges across their interface. The investigations on different scavengers demonstrate that superoxide anion radicals and holes have a significant role in the degradation of ofloxacin.

Intan et al. (2023) [10] report on the synthesis of reduced Ag nanoparticles as a material from cinnamon-decorated ZnO for hexavalent chromium (Cr(VI)) reduction via photooxidation. Though the reaction performance, the Ag nanoparticles possess 63% higher Cr(VI) reduction than the ZnO catalyst alone. This may be due to to the smaller particle size of the composite, which can provide a more active surface and a lower recombination rate for charge carriers. The combination of a low energy band gap and reduced charge recombination increase the photocatalytic efficiency of the proposed composite.

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

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