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Editorial

# Solar Energy Utilization and Photo(electro)catalysis for Sustainable Environment

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Utilizing solar light as a sustainable energy source has been one of the most wanted holy grails in the research communities looking for solutions for sustainable energy and environmental protection. Sunlight is the main driving force for many of the natural terrestrial processes (both physicochemical and biological), but utilization of diffuse sunlight to meet human needs is not easily achieved in a cost-effective way. A popular engineering method to harvest solar energy employs semiconductor materials, which is widely investigated for photo(electro)catalysis. Although photo(electro)catalysis has been originally developed for the need of hydrogen production through the water splitting reaction, it has expanded gradually into environmental engineering problems such as water treatment, air purification, resource recovery, and carbon capture and utilization. In particular, the imminent global climate change demands the carbon neutrality in all fields of engineering and technology, and solar energy-based photo(electro)catalysis could provide ideal solutions for many of the environmental engineering problems. As the photo(electro)catalysis for sustainable environment is an increasingly popular research topic in the environmental engineering community, we felt it timely to prepare a special issue devoted to this topic in *ACS ES&T Engineering*.

This special issue provides an overview of photo(electro)catalytic research activities that are closely related to sustainable environmental issues. The introduced topics include water treatment, air purification, disinfection, $CO_2$ reduction, $H_2$ production, ammonia synthesis from $N_2$, $H_2O_2$ synthesis from $O_2$, and metal recovery. The remediation of polluted water and air has been the most studied topic in environmental engineering, but the available technologies are evolving with time. Photocatalysis has been first employed for water treatment in the 1980s, and since then the field of photocatalytic purification has evolved with the advent of various kinds of semiconductor nanomaterials (Ji et al., Wang et al., Shi et al., Lou et al.). The same working principle has been successfully demonstrated for air purification as well (Cui et al.). A solar-based remediation technology is conceptually similar to nature's self-cleaning process and can be ideally suited for self-standing small-scale systems that can operate even in places that are not connected to the electrical power grid. The urgent need for renewable energy sources and carbon neutrality activates the field of photochemical conversion of $CO_2$ (Lu et al., Li et al., Shi et al.), $N_2$ (Miao et al., Kani et al.), water (Toe et al.), and $O_2$ (Wu et al.), all of which aim for solar light-induced production of fuels and chemicals from earth-abundant substances without the need for any chemical reagents and external power inputs. Solar photocatalysis can also be utilized to recover precious metal from waste (Chen et al.). Scaled-up production of fuels and chemicals through photo(electro)catalysis without the input of fossil fuels enables a carbon-neutral circular economy, which should be the ultimate solution for a sustainable environment.

Despite the popularity of the topic and the intrinsic environmental friendliness of the technology, it should overcome many challenges. The practicality of solar photo(electro)catalysis has been often criticized because of the low photoconversion efficiency, the lack of long-term durability of materials, and the lack of full-scale demonstration. This is ascribed partly to the fact that most research efforts have been focused on materials development, while practical issues such as reactor and system design, scale-up, and optimization have been much less studied. The proper target systems for the application of photo(electro)catalysis should be more elaborately selected and designed. This also guides the direction of future research to make this technology practically more viable and economical. Traditional environmental engineering systems can be actively integrated with the solar-based photo(electro)catalytic technology. This special issue provides some examples and guidelines for environmental engineers who actively seek solutions for a sustainable future. *ACS ES&T Engineering* will continue to be the platform to publish future progress of this field, and we look forward to receiving continued submissions on this topic as one of the key sustainable environmental technologies.

Wonyong Choi

**Wonyong Choi** orcid.org/0000-0003-1801-9386

Fan Dong

**Fan Dong** orcid.org/0000-0003-2890-9964
**Marta Hatzell** orcid.org/0000-0002-5144-4969

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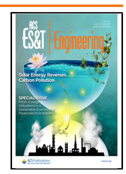

**Guido Mul** orcid.org/0000-0001-5898-6384

## AUTHOR INFORMATION

Complete contact information is available at:
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### Notes

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