

# An Emerging Technological Nexus: Solar-Assisted Energy and Environmental Catalysis

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There have been numerous efforts devoted both to generate clean and renewable fuels using earth-abundant materials and to attenuate serious environmental impacts associated with greenhouse gas emissions (CO<sub>2</sub>). Hydrogen is an ideal fuel carrier for the future and the success of the hydrogen economy requires a safe, efficient and environmentally friendly process for hydrogen production. At the same time, the reduction and/or fixation of CO<sub>2</sub> arising from the burning of fossil fuels is of vital interest to mitigate urgent environmental problems but also as a potential new generation feedstock. The perfect solution to address both growing energy demands and more stringent environmental standards may be reliant on a new phase of green catalysis and sustainable nanoscale technologies that takes advantage of abundant solar energy and delivers tailored function.

This talk will propose strategies to address energy demands and environmental challenges as well as elucidate the crucial role of photocatalysis including (i) the rational design of advanced functional materials, (ii) manipulation of physical and chemical properties, and (iii) achieving high photocatalytic performance through structure-function relationships.<sup>1</sup> I will describe how to engineer semiconductor oxide photocatalysts by wet chemical approaches to successfully manipulate their 0D-3D geometry, structure, electronic and chemical nature. This will include the introduction of defects, active sites, mid-bands, electron donor/acceptor levels and heterojunction at the interface, as well as the functionalization by graphene family to facilitate the separation of charge carriers and achieve strong visible light response.<sup>2-4</sup>

Subsequently, I will demonstrate how these novel photocatalysts work in applications of wastewater remediation and H<sub>2</sub> production from water. This will draw on lab-based and synchrotron radiation tools, comprising microscopic, scattering, spectroscopic, electrochemical and analytical techniques, that have been employed to understand (i) how well the size, shape and composition of nanomaterials can be grown and controlled; (ii) how the alteration in structure, morphology and electronic configuration impact the photocatalytic activity; and (iii) what is the key factor or optimized parameter to achieve the best performance.<sup>2-6</sup>

Finally, I will propose new research thrusts at Texas Tech University, involving the design and synthesis of novel nanostructured photocatalysts for the production of energy-rich fuels from water, wastewater and oxygenates and for the reduction of CO<sub>2</sub> with high quantum efficiency, yield and selectivity. The knowledge obtained at a lab-scale research level on the sub-nano scale will provide an ideal research foundation to engineer real heterogeneous catalysts to better respond to practical industrial applications.

## References

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