UNIVERSITY OF HOUSTON

MATERIALS SCIENCE AND ENGINEERING SPRING 2025 SEMINAR SERIES

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Location: W122 Engineering 2

Nanoscale Innovations for Organic Solar Cells and Multifunctional Materials: From Aesthetic Photovoltaics to Light-Driven Batteries and Sustainable Desalination

The strategic design and integration of nanostructured materials are revolutionizing renewable energy and sustainability technologies. This work presents breakthrough advances across four interconnected domains: aesthetic photovoltaics, underwater solar harvesting, photo-enhanced energy storage, and electrochemical desalination. We demonstrate a new paradigm in building-integrated photovoltaics through color-tunable polymer solar cells that incorporate strategically designed energy transfer dye molecules within non-fullerene polymer systems. These devices achieve both aesthetic appeal and high performance, expanding solar adoption possibilities. Through innovative tape-stripping fabrication, we develop extraordinarily durable solar cells capable of underwater operation without encapsulation, maintaining remarkable efficiencies of 55% in shallow waters and exceeding 65% in deep waters, with sustained power densities above 5 mW cm^{-2}. Advancing materials processing, we pioneer a UV light-assisted CO2 doping technique for perovskite solar cells that enhances conductivity by two orders of magnitude compared to pristine films. This rapid, reproducible method represents a significant breakthrough in scalable perovskite device fabrication. In the realm of energy storage, we reveal how strategic light integration can dramatically enhance battery performance. Our studies of photo-accelerated charging in LiMn2O4 cathodes and Li4Ti5O12 anodes demonstrate significantly improved delithiation kinetics under white light illumination without requiring complex nanostructuring. Through systematic wavelength-dependent studies using LED illumination, we uncover the fundamental mechanism: photo-induced electron-hole pair generation in wide-bandgap materials drives enhanced electrochemical reactions. Furthermore, we present an innovative redox flow desalination system that synergistically combines water purification with energy storage capabilities. This dual-function system effectively captures excess renewable energy during off-peak periods, enabling sustainable water treatment while providing grid-scale energy storage solutions. These advances demonstrate how architectural control at the nanoscale can address critical sustainability challenges, laying the foundation for next-generation energy and environmental technologies.

Bio: Prof. André D. Taylor is a Professor in the Chemical and Biomolecular Engineering Department at New York University, where he leads the Transformative Materials and Devices Group (TMD Lab). His research focuses on the synthesis and integration of nanomaterials into devices such as fuel cells, lithium-ion batteries, and solar cells.