Optoelectronics meets Optoionics:
Energy Conversion and Light Storage in Carbon Nitrides and Beyond

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Harnessing and storing intermittent renewable energy sources such as wind and solar power is essential for building a sustainable energy future. Meeting this challenge requires innovative materials and device concepts that can bridge the gap between light harvesting and energy storage. Inspired by the light and dark reactions of natural photosynthesis, we have recently discovered a new class of light-storing materials capable of absorbing, converting, and storing solar energy through ion-mediated trapping of photoinduced charge carriers.

This talk introduces the emerging field of optoionics[1] and explores its potential for the design of multifunctional materials that seamlessly integrate optoelectronic and ionic processes, exemplified by optoionic 2D carbon nitrides, transition metal oxides, and covalent organic frameworks.[2-4] The coupling of solar energy conversion with electrochemical energy storage opens innovative pathways for next-generation energy systems, including "dark photocatalysis", photomemristive sensors, direct solar batteries, and light-driven microswimmers with photocapacitive behavior. These concepts represent a new paradigm in self-powered, autonomous devices, where energy conversion, storage, and actuation are unified in a single material platform.[5-7]

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