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BIO-TALK - Natural photosynthetic proteins for biosolar cells, biofuels and biosensors: In situ time-resolved spectroelectrochemistry reveals loss channels

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12:30 to 13:30

Blue Lecture Room

Abstract:

Photosynthetic reaction centres catalyse the majority of solar energy conversion on Earth, and achieve this goal with a near-unity quantum efficiency. Capturing this high-efficiency with man-made electrodes is the goal of biohybrid technologies such as biophotovoltaics, biofuel cells, and biosensors. In my talk, I will present numerous strategies we have employed to improve solar energy capture and conversion in biohybrid devices. I will also discuss the numerous limitations that this field faces, focusing on the various loss processes that result from the removal of reaction centres from their natural cellular environment. These loss channels not only compromise device efficiency, but also device stability, sending high electrons down channels that produce ROS, for instance. In our recent publication in Joule, we used combined spectroscopy and analytical electrochemistry to identify electron transfer, bottlenecks, back-reactions and short-circuits that affect the performance of a bacterial reaction centre-based biophotoelectrode. We determined that the system was over 90% efficient under low-Intensity light but dropped to ~11% efficiency under intense continuous illumination. Limitations and loss processes included bottlenecks in electron transfer that rendered 60% of reaction centres inactive, as well as a short-circuiting of 73% of the photochemical product from active reaction centres. These findings will help shape rational design strategies for improving the performance of biohybrid devices and extend to donor-acceptor type photocatalysts. I will end my talk with a brief preview of our current research efforts to redesign photosynthetic proteins for enhanced biosensing using computational bioinformatics and molecular docking.

Profile:

Nature is pretty remarkable. Catching sunbeams and trapping carbon dioxide to make solar fuels are just one of its many tricks. And it does so with near-perfect efficiency - using only a handful of Earth-abundant elements - at room temperature. Can we harness that ingenuity somehow? I think we can. For over a decade, I've been working at the interface between biology and technology, hijacking nature's machinery for generating electricity, solar fuels, and sensors. Using various electrode materials and interfacial optimization strategies, we have managed to boost the efficiency of solar energy capture using proteins adsorbed onto electrodes over 3 orders of magnitude, pushing photocurrents into the mA cm-2 range, and capturing up to 90% of incident solar irradiation in charges trapped at the electrode and in solar fuels. Furthermore, by engineering the protein-electrode interface, we've managed to increase the stability of these biohybrid systems from hours to years. Finally, using computational protein design, we have increased the biosensing sensitivity of herbicides into the picomolar range, ripe for viable application in biosensing technologies.

Hosted by: Prof. Dr. Nicoletta Liguori & Academic Affairs