PhD Projects in Dr. Elisabet Romero Group at ICIQ:

Design, Construction, and Investigation of Chromophore-Protein systems able to perform Ultrafast Energy and Electron Transfer Processes

The motivation for this Project is the need to face the global challenge of achieving a renewable, widespread and inexpensive energy supply towards a sustainable future. The energy of the Sun fulfills these conditions, however, the efficient and inexpensive conversion and storage of solar energy into a fuel remains a fundamental challenge.

Within this Project, the PhD Student will develop a new generation of solar-energy conversion systems based on the design principles of Photosynthesis, the most advanced one being the utilization of coherence\(^1\) (for a recent review see Romero et al., Nature, 2017\(^2\)).

More specifically, the Student will design, construct, and investigate chromophore-protein assemblies (Figure 1) composed by renewable and abundant materials capable to perform efficient and ultrafast energy and electron transfer processes.

![Figure 1. Illustrative chromophore-protein assembly. The chromophores are shown in green and the protein is represented as purple and grey ribbons. (Left) top view, (center) titled side view, (right) side view.](image)

The static and dynamic properties of the newly created assemblies will be studied by several methods, with a strong focus on spectroscopic techniques [time-resolved: Two-Dimensional Electronic Spectroscopy (2DES), Transient Absorption, Time-correlated Single Photon Counting (TCSPC); steady-state: Absorption, Fluorescence, Linear and Circular Dichroism, Stark, Raman, FTIR, Fluorescence Line-Narrowing].

The optimized systems will be integrated into solar cells to generate electricity and, ultimately, they will be coupled to catalysts (developed by collaborators) to construct devices able to achieve cost-effective solar-energy conversion to fuel.

The PhD student background should be on (Bio)Physics or Physical Chemistry.

References


The Role of Coherence in Enhancing the Efficiency of Light Harvesting and Charge Separation in Photosynthesis.

Photosynthesis is the biological process whereby the Sun’s energy is collected and stored by a series of events that convert this energy into the biochemical energy needed to power life. The success of Photosynthesis depends on its initial steps: the ultrafast and highly efficient light harvesting and charge separation mechanisms (that is, energy and electron transfer processes, respectively). During the last decade, growing evidence points to the key role of coherence in determining the high efficiency of Photosynthesis owing to the fact that coherence provides directionality, speed and efficiency to energy and electron transfer processes.

The concept of coherence-enhanced function in Photosynthesis is an ongoing matter of passionate debate within the scientific community because it encloses a fundamental question: Is Photosynthesis, and by extension Nature, utilizing coherence to achieve its amazing efficiency?

Within this Project, the PhD Student will address this question by investigating light harvesting and charge separation processes in a series of natural and genetically-modified photosynthetic complexes.

![Figure 1. The Photosystem II core complex. Chromophores shown as sticks and protein represented as ribbons. The Light harvesting complexes are shown in red and blue, and the reaction center (site of charge separation) in yellow and orange (adapted from ref. 2)](image)

The static and dynamic properties of these complexes will be studied by spectroscopic techniques [time-resolved: Two-Dimensional Electronic Spectroscopy (2DES), Transient Absorption, Time-correlated Single Photon Counting (TCSPC); steady-state: Absorption, Fluorescence, Linear and Circular Dichroism, Stark, Raman, FTIR, Fluorescence Line-Narrowing].

The results obtained will provide both fundamental insights as well as refined design principles to aid in the quest for the rational design of human-made systems to achieve cost-effective solar-energy conversion to fuel.

The PhD student background should be on (Bio)Physics or Physical Chemistry.

References