Eukaryotic Photosynthetic Thylakoid Biohybrids: Probing Fundamental Interactions in Charge Accumulation

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Photosynthesis harnesses energy from the sun, driving electron transport and carbon fixation. Previous work in our lab has shown that negatively charged mercaptosuccinic acid capped platinum nanoparticles (PtNP) are able to self-assemble on positively charged regions of Photosystem I (PSI) near ferredoxin/flavodoxin binding locations. This targeted self-assembly strategy translates to PtNP incorporation at intrinsic PSI sites within thylakoid membranes to achieve complete solar water-splitting systems. Not only can PtNP be used as a H_2 catalyst but also as a bioinorganic probe of fundamental interactions between native electron acceptor proteins and PSI, allowing better understanding of how PSI electron transfer drives the formation of NADPH. When PtNPs are incorporated with thylakoid membranes, electron transport between Photosystem II (PSII) and PSI can be observed. Recent optical transient absorption spectroscopic results show that PtNP acts as an "electron sink" that rapidly "pulls" electrons through the linear electron transfer chain in biohybrid thylakoids. Thus, targeted binding of PtNPs to PSI can potentially be used to "switch" between cyclic and linear electron transport mechanisms. In this work, we explore how different eukaryotic thylakoid membranes across several species (Spinach, *Scenedesmus obliquus,* and *Chlorella vulgaris*) may affect H_2 production efficiencies as well as higher order complex formation between PSI and ferredoxin (Fd) and ferredoxin-$NADP^+$ reductase (FNR). Understanding the fundamental mechanisms of electron transfer between PSII and PSI as well as between PSI and its native protein and abiotic electron acceptors will inform design strategies for sustainable photosynthetic-inspired systems with efficient solar energy conversion and solar fuel synthesis capabilities.