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Biological Inspiration toward Artificial Photostystem

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Imagine a world where we could biomanufacture hybrid nanomaterials having atomic-scale resolution over functionality and architecture. Toward this vision, a fundamental challenge in materials science is how to design and synthesize protein-like material that can be fully self-assembled and exhibit information-specific process. In an ongoing effort to extend the fundamental understanding of protein structure to non-natural systems, we have designed a class of short peptides to fold like proteins and assemble into defined nanostructures. In this talk, I will talk about new strategies to drive the self-assembled structures designing sequence of peptide. I will also discuss about the specific interaction between proteins and inorganics that can be used for the development of new hybrid solar energy devices. Splitting water into hydrogen and oxygen is one of the promising pathways for solar to energy convertsion and storage system. The oxygen evolution reaction (OER) has been regarded as a major bottleneck in the overall water splitting process due to the slow transfer rate of four electrons and the high activation energy barrier for O-O bond formation. In nature, there is a water oxidation complex (WOC) in photosystem II (PSII) comprised of the earth-abundant elements Mn and Ca. The WOC in photosystem II, in the form of a cubical CaMn4O5 cluster, efficiently catalyzes water oxidation under neutral conditions with extremely low overpotential (～160 mV) and a high TOF number. The cluster is stabilized by a surrounding redox-active peptide ligand, and undergo successive changes in oxidation state by PCET (proton-coupled electron transfer) reaction with the peptide ligand. It is fundamental challenge to achieve a level of structural complexity and functionality that rivals that seen in the cubane Mn4CaO5 cluster and surrounding peptide in nature. In this presentation, I will present a new strategy to mimic the natural photosystem. The approach is based on the atomically defined assembly based on the short redox-active peptide sequences. Additionally, I will show a newly identified manganese based compound that is very close to manganese clusters in photosystem II.

Keywords: Artificial Photostystem, Self-assembled peptide structure, Mn cluster, Water Splitting, Protein-like material