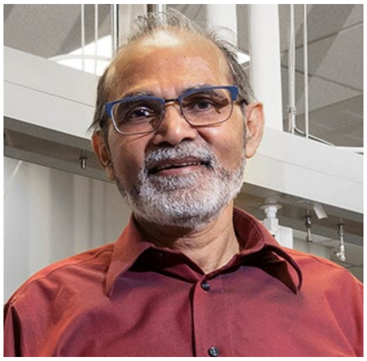
NEBRASKA CENTER
FOR ENERGY SCIENCES RESEARCH

Cycle 17
January 2023



Principal Investigator: Ravi Saraf, Ph.D.
Position Title: Professor
Department: Chemical and Biomolecular Engineering

Email: rsaraf2@unl.edu
Phone: (402) 472-8284
Webpage: https://ncmn.unl.edu/faculty/saraf

Project Title.
Photocatalytic Corrosive Nanostructured Electrode to Split Water

Abstract.
In artificial photosynthesis to split water, a free-energy gradient of “hot” electrons and holes are generated by light to produce hydrogen and oxygen, respectively. In this approach, hot electrons in a semiconducting electrode of bandgap >2V are photo-excited to cause water splitting. Catalysis is enhanced roughly 100-fold by incorporating metallic nanoparticles (mNPs) with the semiconductor electrode. This enhancement occurs due to charge transport from photoexcited mNPs to the semiconductor. The hot electrons generated by the localized surface plasmon resonance (LSPR) are injected into the conduction band of the semiconductor to mediate the reaction. This strategy is attractive because it enables accessibility to a broad portion of the visible solar spectrum to harvest hydrogen (H2) from water. In this research, a unique nanostructure incorporating both the mNPs and semiconductor in a monolith architecture will be developed to sustain both cathodic and anodic processes on the same electrode, kin to corrosion phenomena. The nanoscale dimensions of metal and semiconductor will shorten the carrier transport length for efficient catalytic activity, which is a critical limitation in the current systems. The nanostructure will be a multi-junction nanoparticles necklaces network (N3) composed of Au-NPs that are nano-cemented with II-VI semiconductor. The two-year fundamental and applied research will combine both experiment and simulation. Three semiconducting nano-cements will be studied to quantitatively tune the N3 topology to operate in the solar spectrum. The landscape of optical field distribution due to LSPR on actual electron microscope images will be computed by electromagnetic simulation to gain deeper understanding of the mechanism. From the structure-property relationship for optimum N3, in the second year, a photo-electrochemical-cell will be engineered to split water. The proposed research on development of catalytic process to improve H2 production will ultimately impact energy storage and management. The research will lead to proposals to NSF/CBET and DOE/BES.