The Bionic Leaf: Developing a Novel Self-Healing, Bi-Functional Manganese Oxide Catalyst to Use With the Bacterium Ralstonia Eutropha for Sustainable Ethanol Production

Gurumukhi, Arya (School: Plano East Senior High School)

Globally, centralized grids leave 940 million people in low - income communities without reliable electricity access, while simultaneously contributing to climate change through carbon emissions. Hence, in this research, a revolutionary "Bionic Leaf" capable of producing high - efficiency fuels by emulating photosynthesis is developed. The engineering goal is to create a Bionic Leaf with a solar storage efficiency of 85% and produce 80 mg / L of ethanol over 100 hours, while being environmentally sustainable and cost - effective. A key factor in achieving this engineering goal was the synthesis of a novel bi - functional, self - healing catalyst material. Manganese oxide was synthesized with the sol - gel process to create 1D nano-rods. It was then doped with iron to create oxygen vacancies and cobalt bismuth to make the catalyst self - healing. These oxygen vacancies and 1D nanorods improve conductivity and reaction speed tremendously. The resultant catalyst material, combined with a binder solution and an amorphous photovoltaic cell, forms the basis of the Bionic Leaf. This leaf is then incorporated in the three-electrode cell setup with the genetically modified bacterium Ralstonia eutropha, which had its PHB gene deleted and adhE gene overexpressed to redirect its carbon flux to release ethanol more efficiently. Remarkably, over 300 charge and discharge cycles demonstrated no signs of degradation. Surpassing the engineering goals, the fuel exhibited a power density and energy density comparable to modern diesel, all achieved sustainably for $5. Future endeavors aim to further enhance solar efficiency and fuel production levels, exploring advanced nano-synthesis techniques.

Awards Won:

Fourth Award of $600

Robert Silence Fund: Robert Silence "Citizen Scientist" Sustainability Award