



**CALIFORNIA SCIENCE & ENGINEERING FAIR  
2019 PROJECT SUMMARY**

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| <b>Name(s)</b><br><b>Laura Noronha</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | <b>Project Number</b><br><b>S0616</b> |
| <b>Project Title</b><br><b>Z-Scheme Photocatalysis: A More Systematic Approach with alpha-Fe<sub>2</sub>O<sub>3</sub>@Au@P-SiO<sub>2</sub>@Cu<sub>2</sub>O Nanostructure</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |                                       |
| <b>Abstract</b><br><b>Objectives</b><br>Create a nanostructure using iron oxide nanorods (Fe <sub>2</sub> O <sub>3</sub> ), gold (Au), porous silica (P-SiO <sub>2</sub> ), and cuprous oxide (Cu <sub>2</sub> O) that mimics the Z-scheme mechanism for hydrogen production.<br><b>Methods</b><br>First synthesize FeOOH nanorods to be used as template. Apply cystamine solution to modify the surface so gold nanoparticles can be attached. Prepare gold nanoparticles and mix them with cys modified iron oxide template. The next step is to coat the FeOOH@Au with SiO <sub>2</sub> . Once the silica is coated, the sample must be calcined to convert the iron oxide to its alpha form (hematite). Next, partially etch the silica to create a porous silica shell. Then, prepare the CuCl <sub>2</sub> stock solution and react with NaOH and NH <sub>2</sub> OH·HCl. Finally, mix with Fe <sub>2</sub> O <sub>3</sub> -Au-SiO <sub>2</sub> solution to obtain Fe <sub>2</sub> O <sub>3</sub> -Au-SiO <sub>2</sub> -Cu <sub>2</sub> O.<br><b>Results</b><br>A standard photocatalytic chamber was used for the testing. Gas chromatography was utilized to measure the production of hydrogen and oxygen gases. Compared to the amount of hydrogen produced from Au, Cu <sub>2</sub> O, Au@Cu <sub>2</sub> O, or Fe <sub>2</sub> O <sub>3</sub> @Au@Cu <sub>2</sub> O, hydrogen production proved most efficient with the alpha-Fe <sub>2</sub> O <sub>3</sub> @Au@P-SiO <sub>2</sub> @Cu <sub>2</sub> O z-scheme photocatalyst. More than three times the hydrogen was produced compared with the photocatalyst that did not have the porous silica, and about 16 times more was produced compared to using gold alone.<br><b>Conclusions</b><br>This z-scheme photocatalyst mimics photosynthesis by using two-light sensitive semi-conductors and a conductor (electron transport chain) to produce hydrogen and oxygen gas. The z-scheme structure enhances photocatalytic activity and is highly efficient in the production of hydrogen gas which can be used as a cleaner and more renewable source of energy. |                                       |
| <b>Summary Statement</b><br>I created a photocatalyst that mimics the Z-scheme mechanism in the light reactions phase of photosynthesis. This structure enhances water splitting for hydrogen production.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |                                       |
| <b>Help Received</b><br>My mentor Rashed Aleisa from Dr. Yin's Lab in UCR helped me design the procedure based on available materials and equipment. TEM images were taken by my mentor.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |                                       |