Team 18: Planthanum

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Problem Statement

Fossil fuels are harmful to the environment, and current methods of hydrogen fuel production lack the accessibility to be utilized by members of underdeveloped communities. Hydrogen gas (H_2) can be produced cleanly and efficiently by splitting water (H_2O) into both H_2 and O_2 via electrolysis.

Project Description

Team 18 designed a process to produce lanthanum (III) iron oxide ($LaFeO_3$). $LaFeO_3$ is a photocatalyst used for solar generation of H_2, and its nanoparticles are used as a novel alternative for semiconductors to coat photoelectrodes. Current semiconductors used in photoelectrodes need "external bias," which means they need DC voltage to operate. Photoelectrodes coated in the $LaFeO_3$ photocatalyst do not require any external bias!

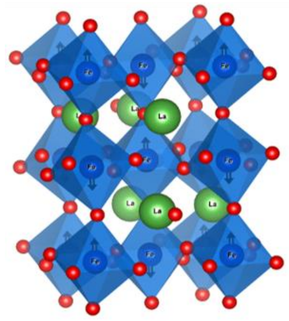

Figure 1. Crystal Structure of $LaFeO_3$.

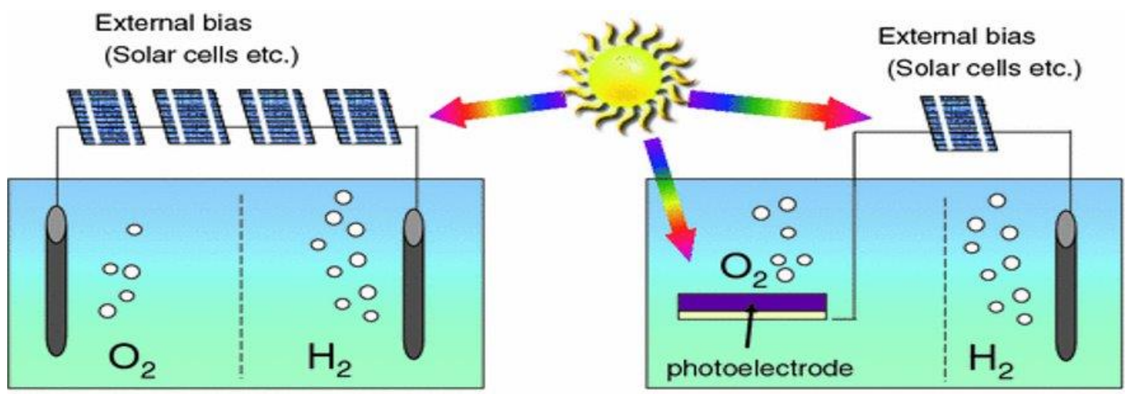

Figure 2. Comparison of Electrolysis. Photoelectrodes Reduce the Need of External Bias to Achieve Electrolysis.

References

- Pawar, Govinder S., and Asif A. Tahir. "Unbiased Spontaneous Solar Fuel Production Using Stable lafeo3 Photoelectrode." *Nature News*, Nature Publishing Group, 22 Feb. 2018, https://www.nature.com/articles/s41598-018-21821-z.
- Suslova, E. V., et al. "Lanthanum Alkoxides. Crystal Structure of [la6(μ6-Cl)(μ3-OPR I)2(μ-OPR I)9(OPR I)6]." *Russian Journal of Inorganic Chemistry*, Pleiades Publishing, 24 Oct. 2015, https://link.springer.com/article/10.1134%2FS0036023615110182

Team Members

From top to bottom:

- Michael Rettstatt (ChE)
- Plinio Rosales Lopez (ChE)
- Josh Broekhuizen (ChE)
- Advisor: Dr. Andrew Wilson (not pictured)
- Industrial Consultant: Randy Elenbaas (not pictured)

Process

Top Section Chemistry: $$LaCl_3 + 3C_2H_5OH + \overset{Bu_4NBr}{\Longleftrightarrow} La(OC_2H_5)_3 + 3HCl$$

Etherification of Lanthanum Salt. Lanthanum chloride is combined with ethanol to create lanthanum ethoxide with a hydrochloric acid waste stream.

Bottom Section Chemistry: $$Fe(NO_3)_3 + 3NH_4OH + \overset{MeOH}{\Longleftrightarrow} Fe(OH)_3 + 3NH_4^+ + 3NO_3^-$$

Precipitation of Iron Hydroxide. Iron nitrate is combined with ammonium hydroxide to precipitate iron hydroxide, which is washed and filtered out of the wastewater stream.

$LaFeO_3$ Reactor Chemistry: $$La(OC_2H_5)_3 + Fe(OH)_3 \overset{TFA,MeOH}{\Longleftrightarrow} LaFeO_3 + 3(C_2H_5OH)$$

Annealing of Lanthanum Iron Oxide. The solid powders are mixed with TFA and annealed at 550℃ for 3 hours to produce lanthanum iron oxide.

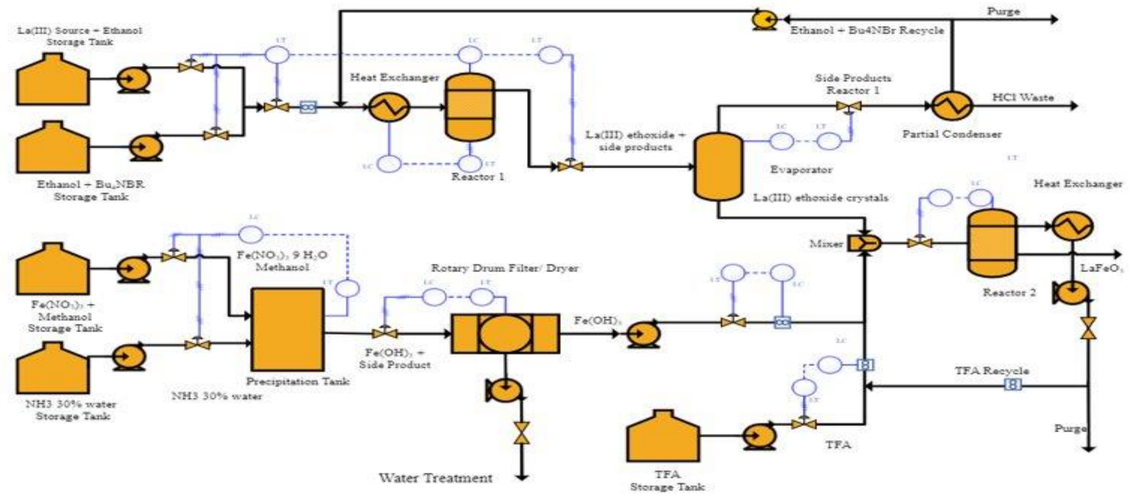

Figure 3: Process Flow Diagram.