CABBI
CENTER FOR ADVANCED BIOENERGY AND BIOPRODUCTS INNOVATION

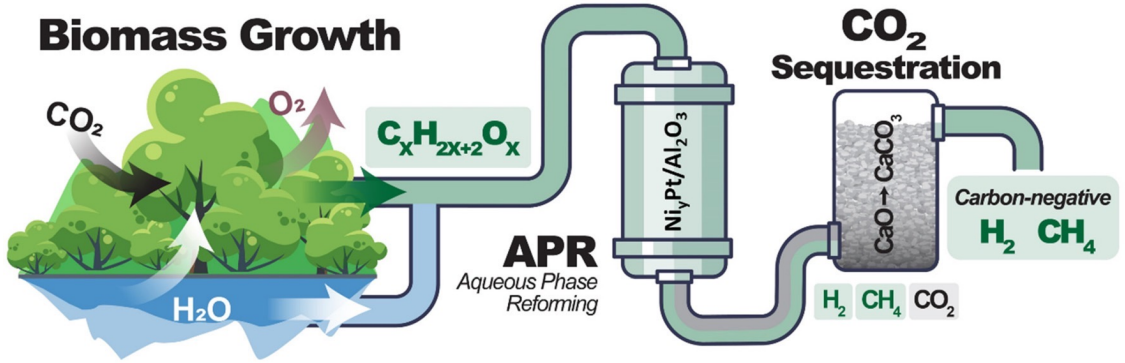
# Carbon-Negative Hydrogen: Aqueous Phase Reforming (APR) of Glycerol over NiPt Bimetallic Catalyst Coupled with $CO_2$ Sequestration

## Background/Objective

Hydrogen ($H_2$) is an important chemical in refining processes, ammonia production, energy storage, and as an alternative and cleaner fuel. Biomass captures $CO_2$ from the atmosphere during the process of photosynthesis. Using biomass to produce $H_2$ offers the advantage of producing $H_2$ from a low-carbon source. Combining $H_2$ production from biomass with carbon capture and storage during $H_2$ production has the potential to produce carbon-negative $H_2$. Herein we report the production of high-pressure, carbon-negative $H_2$ from glycerol.

## Approach

Aqueous phase reforming (APR) of 10 wt% glycerol solution was studied with a series of Nickel Platinum (NiPt) alumina bi-metallic catalysts supported on alumina. The adsorption capacity of the CaO adsorbent was measured at different temperatures.




**Schematic representation of a process to produce carbon-negative $H_2$ from biomass-derived compounds through APR technology and $CO_2$ sequestration.**

## Results

The $Ni_8Pt_1$-450 catalyst had the highest hydrogen selectivity (95.6%) and the lowest alkanes selectivity (3.7%) of the tested catalysts. The hydrogen selectivity decreased in the order of $Ni_8Pt_1$-450 > $Ni_8Pt_1$-260 > $Ni_1Pt_1$-260 > Pt-260. Life cycle analysis showed that the APR of glycerol coupled with $CO_2$ capture has net negative $CO_2$ equivalent greenhouse gas emissions of −9.9 kg $CO_2$ eq./kg $H_2$ and −50.1 kg $CO_2$ eq./kg $H_2$ when grid electricity and renewable electricity are used, respectively, and the $CO_2$ is allocated respectively to the mass of products produced. The cost of this $H_2$ was estimated to be 2.4 USD per kg $H_2$ when grid electricity is used and 2.7 USD per kg $H_2$ when using renewable electricity. The cost of glycerol has the highest contribution of 1.71 USD per kg $H_2$.

## Significance/Impacts

This study shows that combining $H_2$ production from biomass with carbon capture and storage during $H_2$ production has the potential to produce carbon-negative $H_2$.

Santiago-Martinez et al. 2024. “Carbon-Negative Hydrogen: Aqueous Phase Reforming (APR) of Glycerol over NiPt Bimetallic Catalyst Coupled with $CO_2$ Sequestration.” *Green Chemistry.* DOI: 10.1039/D4GC01896F.