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DYNAMIC MODELLING OF HYDROGEN PRODUCTION FROM PHOTO-FERMENTATION IN MICROBIAL ELECTROLYSIS CELL USING SAGO WASTE

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INTRODUCTION

- Diminishing of the conventional fossil fuel reserves in the future
- Hydrogen – promising alternative fuel (high efficient energy carrier), viable, sustainable and zero emission combustion [only generate by-product of water vapour + thermal]
- Currently, reforming of fossil fuel is widely used for the substantial hydrogen supply but technologically not efficient
- Biomass as a promising replacement to fossil fuel for a sustainable bio-hydrogen production

RESEARCH PROBLEMS

- Sago waste increases due to the rising of sago commercialisation in Sarawak, thus require a good waste management strategy
- MECs alone break down carbohydrates slowly and produce low hydrogen purity

Scope of Studies

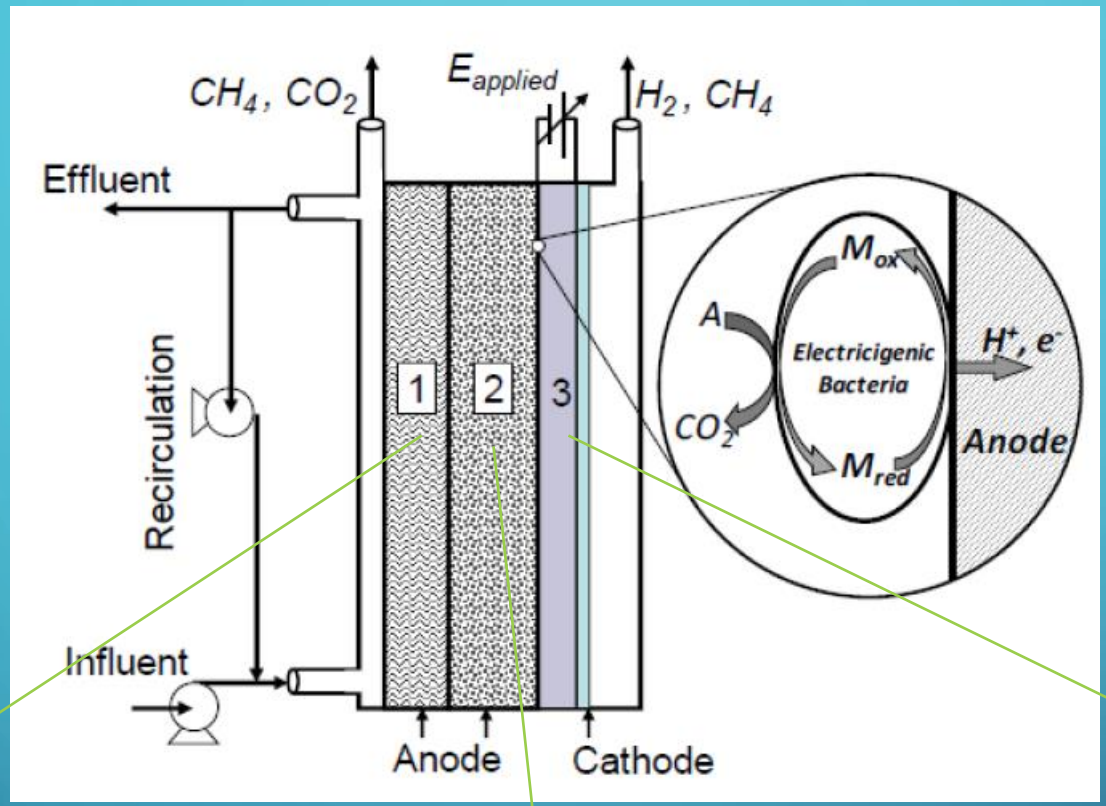
- Use sago waste as a raw materials in the Microbial electrolysis cell (MEC) for biohydrogen production
- Integration of MEC with a photo-fermentation – complete and efficient conversion
- Mathematical modelling – reaction and kinetic studies

RESEARCH OBJECTIVES

- To establish mathematical model for bio-hydrogen production in the MEC with the integration of photo-fermentation by using sago's waste
- To study in depth the chemical reaction of bio-hydrogen production in the integrated MEC-photo-fermentation
- To observe the influences of the concentration of microbial community on the hydrogen production at batch process in which including the parameters as following:
  - Substrate concentration
  - Fermentative microorganism concentration
  - Electricigenic microorganism concentration
  - Hydrogenotrophic methanogens concentration
  - Microbial Electrolysis Cell (MEC) current

FINDING AND DISCUSSION

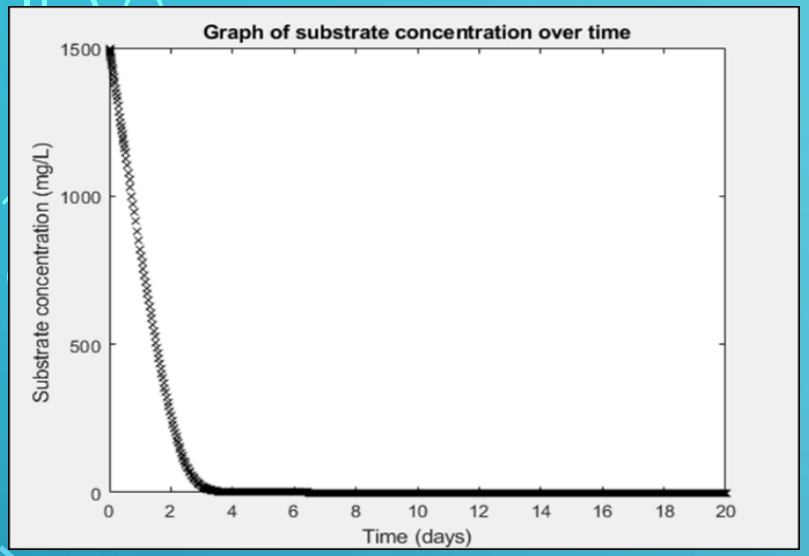
MEC PERFORMANCE BASED ON THREE BIOFILM LAYERS MODEL (PINTO,2011)

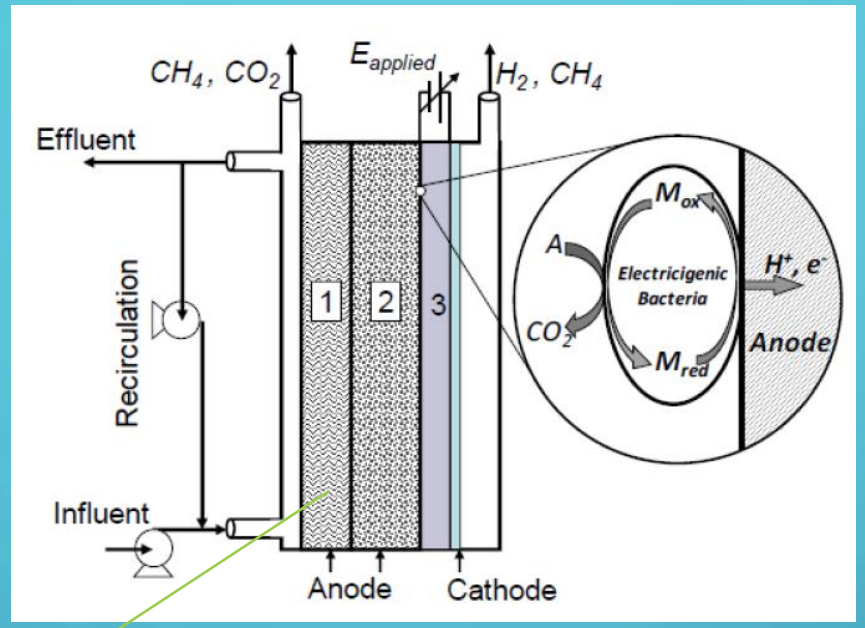


Layer 1: Outer biofilm at anode	Layer 2: Inner biofilm at anode	Layer 3: Biofilm at cathode
Fermentative microorganism Sago waste (substrate) ⟶ acetate Acetoclastic methanogens Acetate - - - - - - - - - → methane	Electricigenic bacteria Acetate ⟶ CO_2 + proton + electron Acetoclastic methanogens Acetate ⟶ methane	Electricigenic bacteria + current H^+ + electron ⟶ Hydrogen gas Hydrogenotrophic methanogens Hydrogen gas - - - - - - - → methane

MEC PERFORMANCE BASED ON THREE BIOFILM LAYERS MODEL (PINTO,2011)

1





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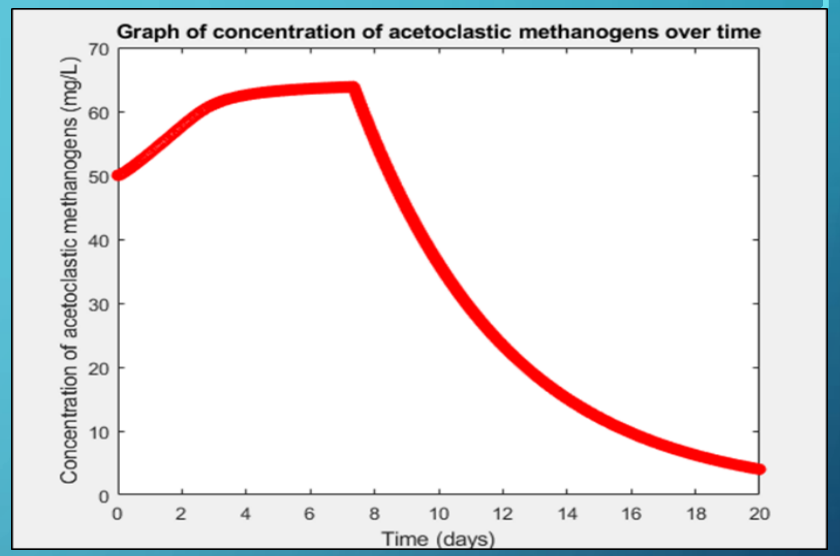

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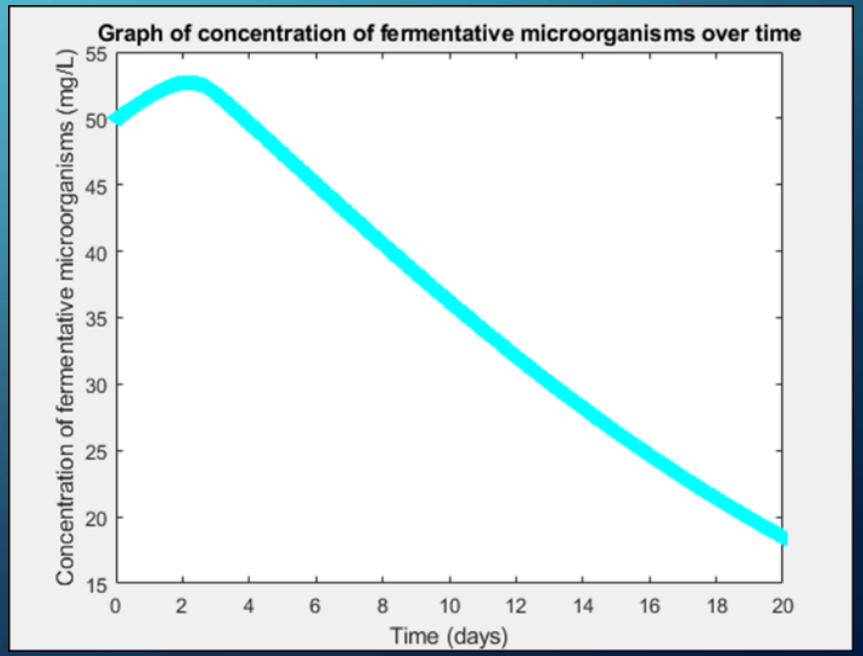


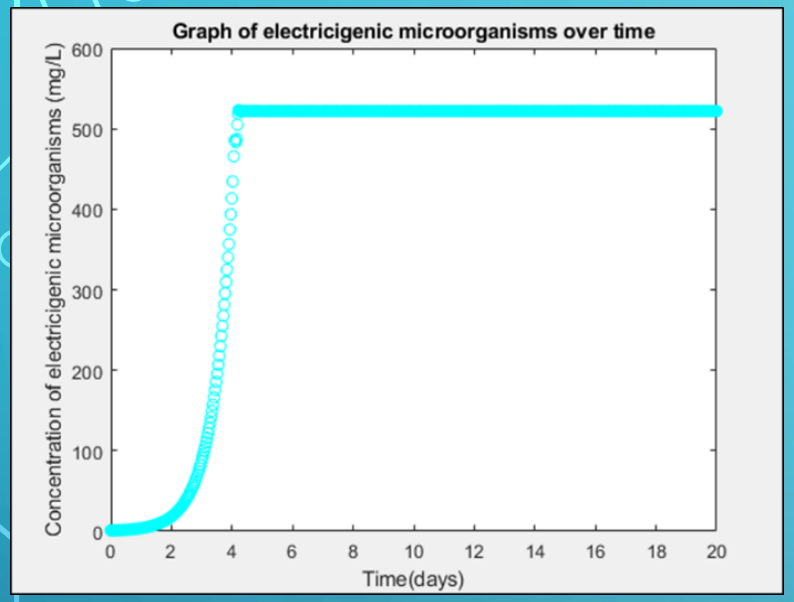
Layer 1: Outer biofilm at anode

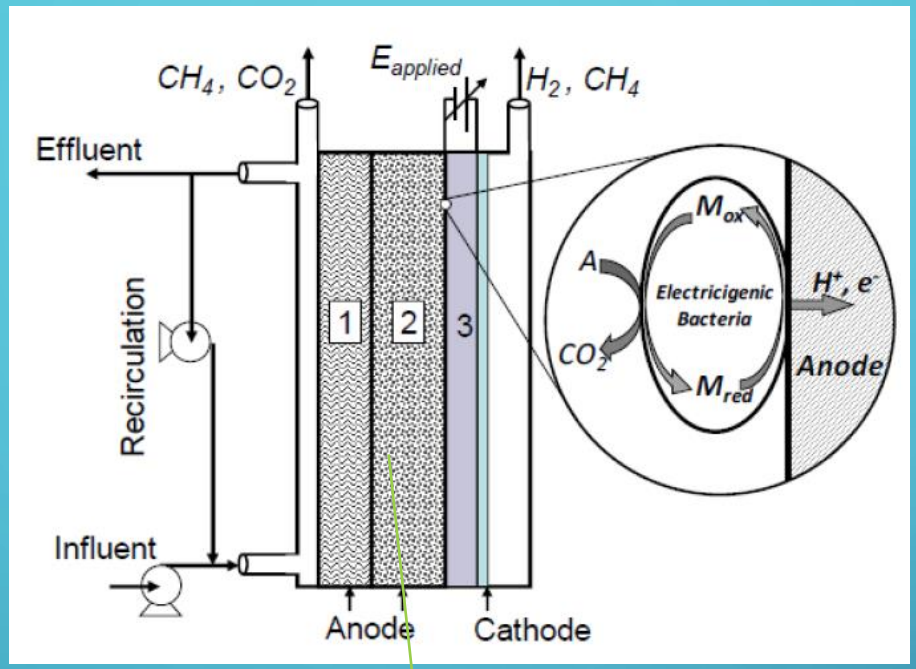
1 & 2 Sago waste (substrate) —Fermentative microorganism→ acetate

3 Acetate - - -Acetoclastic methanogens→ methane

MEC PERFORMANCE BASED ON THREE BIOFILM LAYERS MODEL (PINTO,2011)

4





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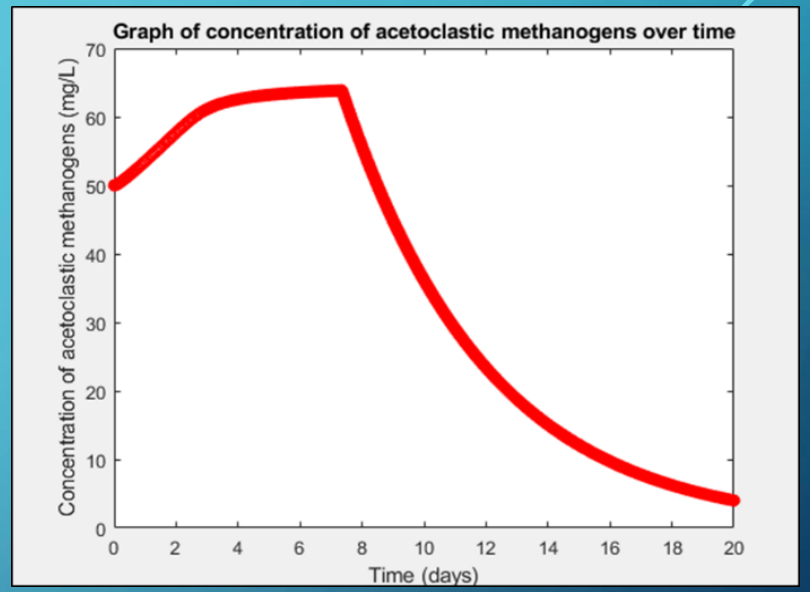


Layer 2: Inner biofilm at anode

4 Electricigenic bacteria

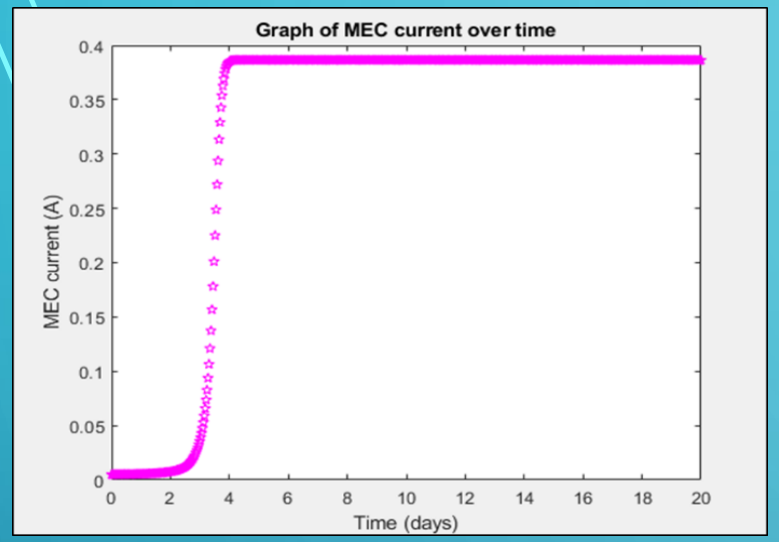
Acetate ⟶ CO_2 + proton + electron

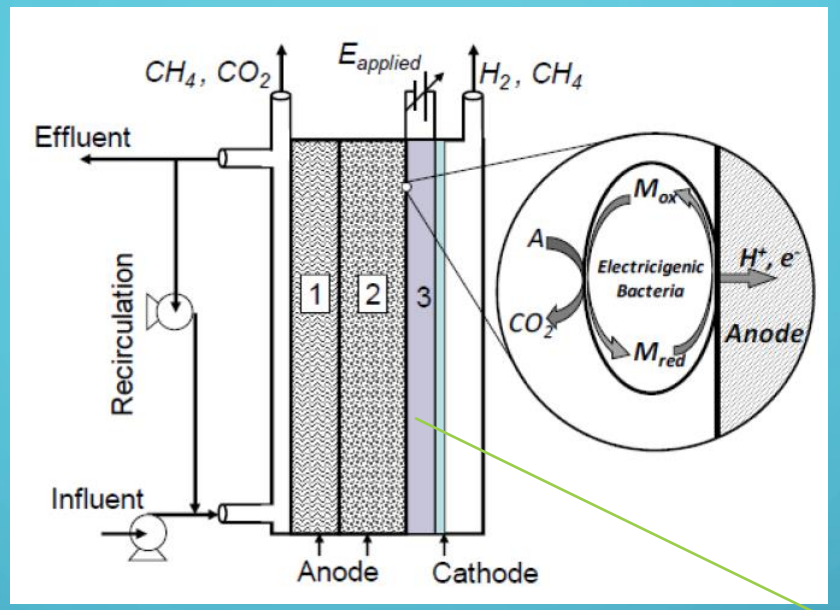
3 Acetoclastic methanogens

Acetate ⟶ methane

MEC PERFORMANCE BASED ON THREE BIOFILM LAYERS MODEL (PINTO,2011)

6





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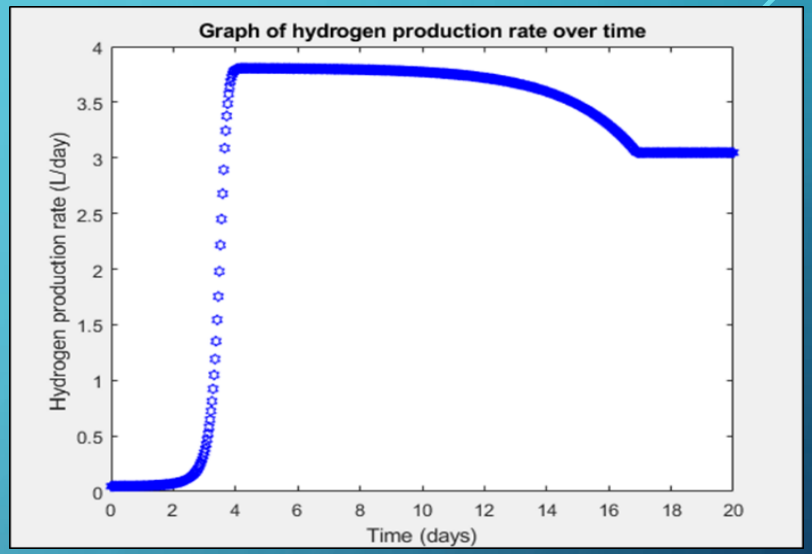

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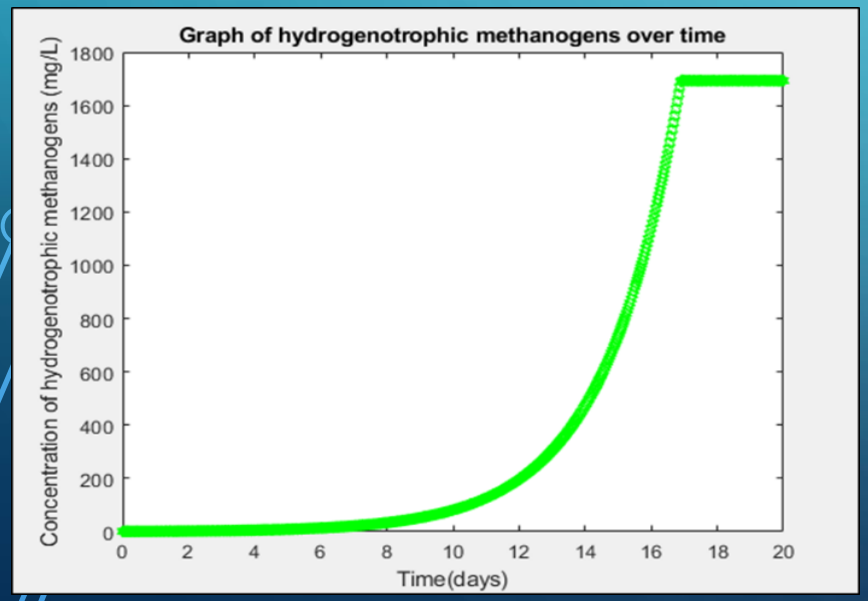

6 & 7

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Layer 3: Biofilm at cathode

Electricigenic bacteria + current

H^+ + electron → Hydrogen gas

Hydrogenotrophic methanogens

Hydrogen gas → methane

CONCLUSION AND FUTURE WORKS

- A mathematical model of the MEC with integrated of photo-fermentation for hydrogen production has been developed and modified by using sago effluent as a substrate in a batch process mode.
- Electricigenic microorganism > acetoclastic methanogens = desirable hydrogen production
- Maximum 3.8 L of hydrogen per day can be generated at MEC current of 0.38 A and hydrogenotropic methanogen concentration of 10 mg/L (less methane is emitted)
- Model is able to predict and correlate between hydrogen production with concentration of electricigenic microorganism and MEC current.
- The model will be further optimized with the main objective to maximize the hydrogen production