Synthesis of hydrogen gas using silver nanoparticles as photo-catalyst in the photo-fermentation of blue-green algae

1. ABSTRACT

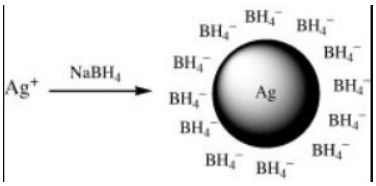
The global energy consumption is increasing, resulting in a greater demand for energy resources. Yet, traditional fossil fuels are posing a great threat to the environment and are gradually running out. A cleaner alternative has to be found such as hydrogen. Besides, photo-fermentation is almost 100% efficient to transfer solar energy to molecular reaction centers for conversion into chemical energy without loss to heat as the process is instantaneous. (Jesus, 2008) Silver nanoparticles with unique surface plasmon resonance property offers promising plasmonic photocatalysts for organic pollutant degradation and water purification. (Wang, 2011) A combination of blue-green algae and silver nanoparticles provides a greener way to produce hydrogen via photo-fermentation would offer hope to a more

Hydrogen gas is a clean and renewable energy source which can be constantly produced by the photo-fermentation of green algae. Due to hydrogen's carbon- neutral property, hydrogen gas is regarded as a green fuel that emits no air pollutants throughout the whole extraction process. Besides, the major benefit of using silver nano particles as the photocatalyst is that they are highly antibacterial.(Sotiriou, 2010) In this study, the photo-catalytic effect of silver nanoparticles on algae for the production of hydrogen is being investigated.

2. THEORY

Production of silver nanoparticles

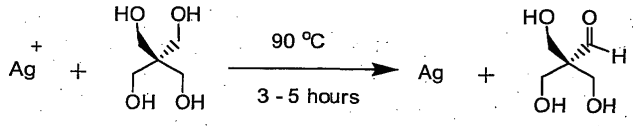
From sodium borohydride and silver nitrate



$$AgNO_3 + NaBH_4 \rightarrow Ag + 1/2\,B_2H_6 + 1/2\,H_2 + NaNO_3$$

(Moghaddam, 2014)

From sodium citrate and silver nitrate



https://www.google.com/patents/WO2012074355A1?cl=en

Hydrogen gas produced by hydrogenase in green algae

https://public.ornl.gov/site/gallery/originals/422_original.jpg

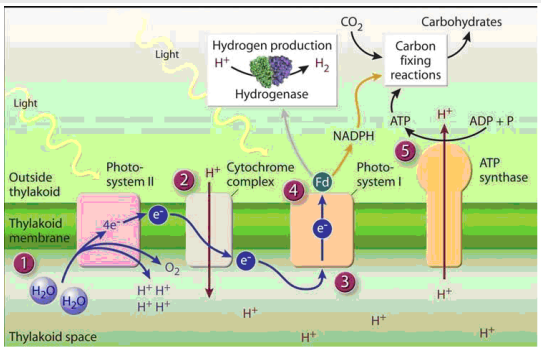


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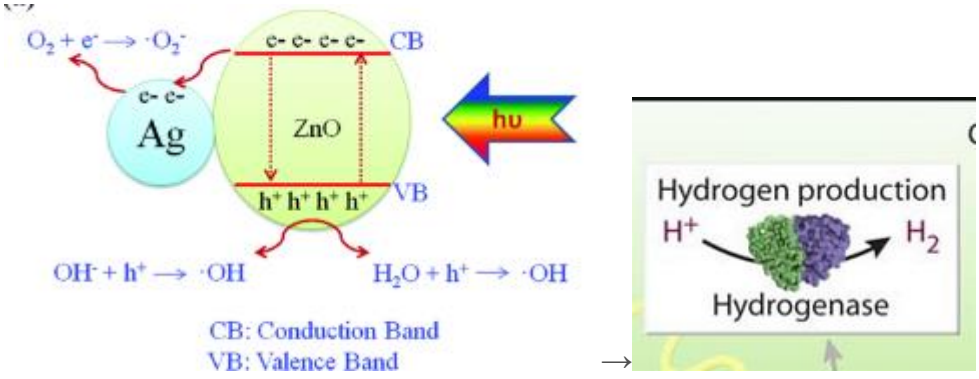
Photo-catalytic effect of silver nanoparticles

Highly reducing electrons are produced during the photo-catalytic action of silver nanoparticles. When hydrogenase anchors on silver nanoparticles, the highly reducing electrons produced can enhance the production of hydrogen gas by hydrogenase.



(Adhikari, 2015)

Nanosight NS300 at the Hong Kong Polytechnic University

Measurement of size and concentration of silver nanoparticles using NanoSight

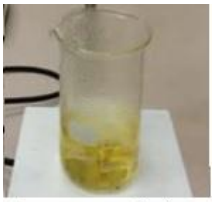
https://www.malvern.com/en/products/product-range/nanosight-range/nanosight-ns300

The Malvern NanoSight NS300 provides a reproducible platform fornanoparticle characterization. It allows automated analysis of thesize distribution and concentration of nanoparticles from 10nm to 2000nm in diameter.

3. METHODOLOGY

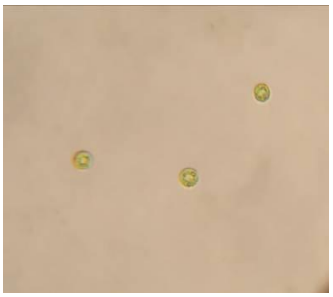
A. Production of silver nanoparticles using sodium borohydride $NaBH_4$ and sodium citrate.

Silver nanoparticles of mode size 43nm 3.63pM formed between $NaBH_4$ and silver nitrate solution



Ag nanoparticles of mode size 3nm 3.98pM formed between sodium citrate and silver nitrate solution

B. Production of hydrogen gas from the photo-fermentation of green algae using silver nanoparticles as photo-catalyst



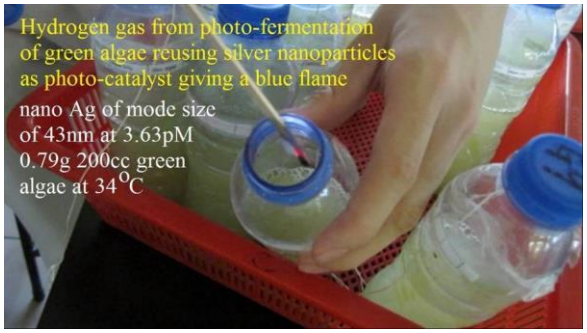
Green algae used

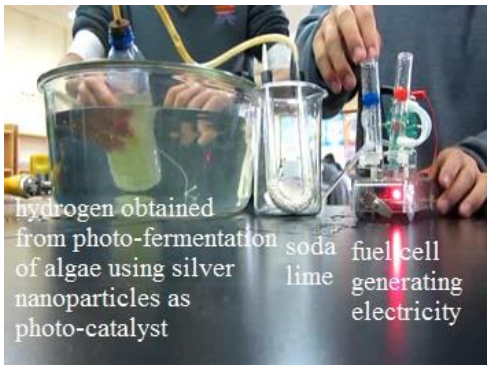
C. **Determination of the concentration of hydrogen gas produced during photo-fermentation of green algae.**

1. The concentration in %LEL was measured using a hydrogen meter.

D. Measurement of size and concentration of silver nanoparticles using NanoSight

E. Testing the combustibility of hydrogen obtained





F. Generating electricity using fuel cell

4. RESULTS

1. Silver nanoparticles of different sizes were obtained from silver nitrate using sodium borohydride and sodium citrate as the reducing agent respectively. Photo-catalytic effect was pronounced when the percentage by volume of
   a. **silver nanoparticles (3.63pM 43nm using $NaBH_4$ as reducing agent), were 37.5% and 25% and green algae concentration of ≧0.2g/200cm^3**
   b. **silver nanoparticles (3.98pM 3nm using $Na_3C_6H_5O_7.2H_2O$ as reducing agent), was 5% and green algae conc. 0.58g/200cm^3**
   c. photo-catalytic effect upon photo-fermentation of green algae in the production of hydrogen gas was **significant at 34℃.**
2. **Silver nanoparticles (43nm 3.63pM; 50cc 25%) were reusable as photo-catalyst with green algae (0.79g/ 200cm^3).**
3. Hydrogen meter was used to measure the concentration of hydrogen gas and the result obtained are **100%LEL (lower explosive limit) i.e. 4% by volume or 40000ppm.**
4. Hydrogen obtained was combustible to give **blue flame.**
5. The hydrogen produced by photo-fermentation of algae can also **generate electricity in a fuel cell**.

In sum, hydrogen gas produced from photo-fermentation of green algae can be developed as a new source of clean and renewable energy for the world and helps alleviate climate change.