

A. Inspiration

Silver nanoparticles (AgNPs) are used world-wide nowadays as anti-bacterial agents (Quay, 2015) and photo-catalysts (Roy, 2015). The lifetime of AgNPs could be prolonged if stabilized by starch, for instance.

In our investigation, starch-stabilized AgNPs were first obtained via a green method by using glucose as reducing agent in a microwave (700W) at medium power. The size of the starch-stabilized AgNPs obtained was studied using JEOL-7100F SEM at HKUST and ZetaPlus (Zeta Potential / Nano-particle Analyzer) at HKUST. The anti-bacterial effect and photo-catalytic effect of starch-stabilized AgNPs were investigated.

B. Theory

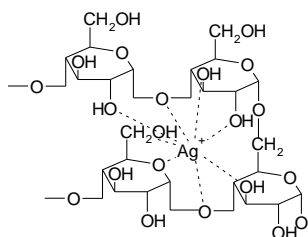
As a chalcogen, oxygen atoms which possess lone pair of electrons in -OH of starch is important in the stabilization of silver nanoparticles (AgNPs). These lone pairs are readily available for the formation of weak forces with transition metal atoms or ions. Starch serves as the surface passivation reagents (making a material becoming "passive," that is, less affected or corroded by the environment of future use. Passivation involves creation of an outer layer of shield material that is applied as a microcoating.), including functional groups such as -OH in starch molecules, are needed to prevent the silver nanoparticles from aggregation. The surface modification of these colloidal nanoparticles is very important to facilitate their application to biotechnology and nanocomposites

1. Production of starch-stabilized silver nanoparticles

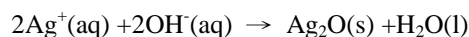
A 4.5-minute microwave reaction is applied to convert silver ions to silver nanoparticles (AgNPs) of size less than 10 nanometers at a high conversion percentage of >99%. The production rate is specific with an energy input of $5.75 \text{ mg AgNP L}^{-1} \text{ min}^{-1} \cdot 5.45 \text{ W mL}^{-1}$ reaction volume was developed. The reduced glucose and starch-stabilized particles remain colloidally stable with less than 4% change in the surface plasmon resonance band at 425-430 nanometer within 300 days. (Kumar, 2017)

It is highly possible that weak forces are formed between the oxygen in the -OH groups of starch and silver nanoparticles. This helps stabilizing the silver nanoparticles. (Balavandy, 2014)

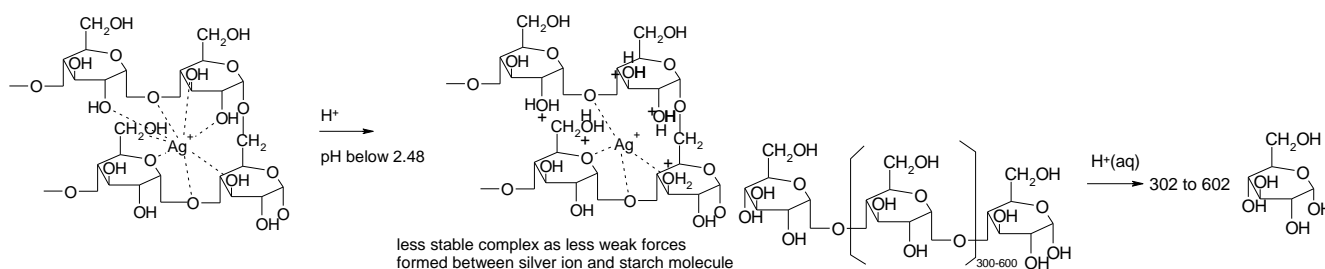
In a similar way, starch could also serve as passivation agent to stabilize AgNPs. A possible structure is suggested as follows.



2. Extreme pH values may cause the complex to collapse. In alkaline medium such as 11.5, precipitation of silver ion takes place as follows.



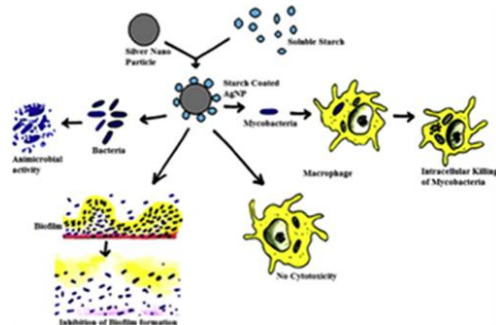
In acidic medium, the complex is relatively stable between 4.48 to 7. However below pH 2.48, the complex probably collapses as protonation between hydrogen ions and the oxygen atoms of -OH takes place as follows.



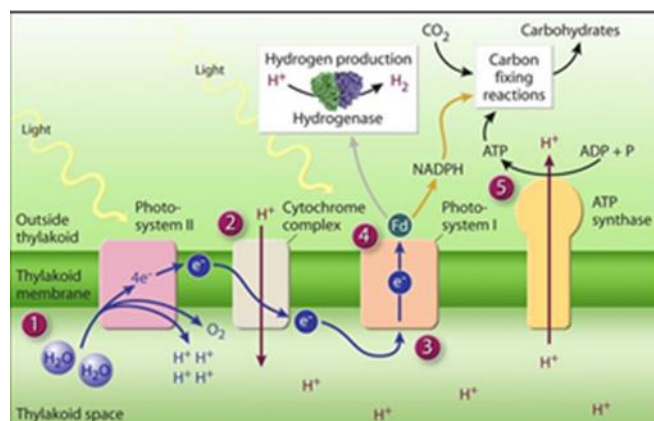
Starch may even hydrolyze (above) to give much shorter fragments and no longer serve as passivation agent.

During hydrolysis, starch become small fragments or even glucose molecules.

3. Silver nanoparticles (AgNPs) are used world-wide nowadays as anti-bacterial agents (Quay, 2015)



and photo-catalysts (Roy, 2015). The lifetime of AgNPs could be prolonged if stabilized by starch, for instance. In our investigation, starch-stabilized AgNPs were first obtained via a green method by using glucose as reducing agent in a microwave (700W) at medium power. The size of the starch-stabilized AgNPs obtained was studied using JEOL-7100F SEM at HKUST and ZetaPlus (Zeta Potential / Nano-particle Analyzer) at HKUST. The anti-bacterial effect and photo-catalytic effect of starch-stabilized AgNPs were investigated. (Mohanty, 2012)



D. Methodology

1. Procedures of production of starch-stabilized silver nanoparticles

1. 16mL of 0.12M silver nitrate solution, 24mL of 0.018M glucose as well as 40mL of 3.4g/L starch solution were added to a conical flask and shaken thoroughly.

2. The mixture was microwaved (700W) for 2½ minutes at medium power.

2. Investigation on the size of nanoparticles

The size of starch-stabilized silver nanoparticles was measured by JEOL-7100F SEM and ZetaPlus (Zeta potential/Nano-particle Analyzer) at Hong Kong University of Science and Technology.

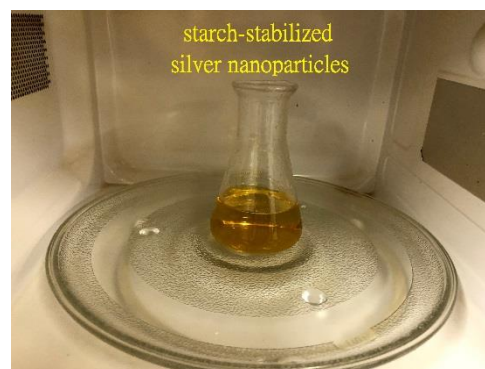


Fig. 4.1 Microwave of 700W



JEOL-7100F SEM
at HKUST



ZetaPlus (Zeta Potential /
Nano-particle Analyzer) at
HKUST

3. Investigation of the antibacterial effect of starch-stabilized silver nanoparticles

4. Investigation of the photo-catalytic effect of starch-stabilized silver nanoparticles in the photo-fermentation of blue green algae

Control (without silver nanoparticles)

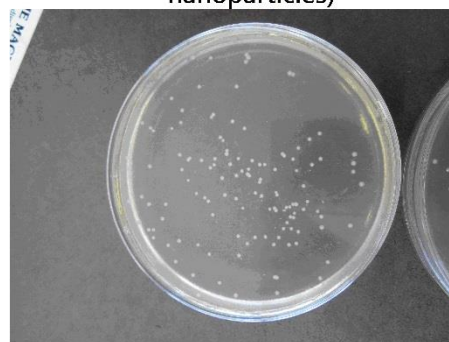


Fig. 4.3.1 Growing oral bacteria using drinking water from the mouth of drinking bottles of everyday use

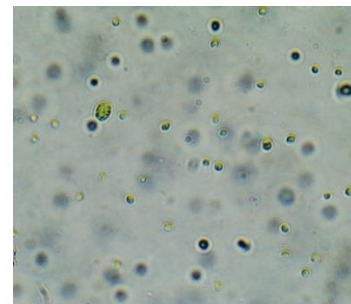


Fig. 4.4.1 Photo of blue-green algae used this investigation at 800X

Fig. 4.4.2 Photo-fermentation of blue-green algae using starch-stablized AgNPs



5. Investigation of the concentration and combustibility of the hydrogen gas obtained from photo-fermentation of blue green algae

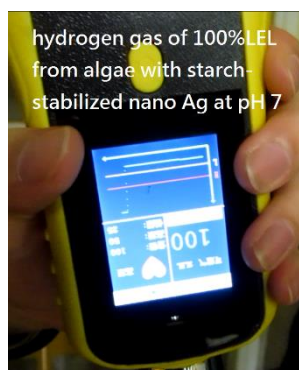


Fig. 4.5.1 Hydrogen gas meter



Fig. 4.5.2 Using a burning splint to test for combustibility

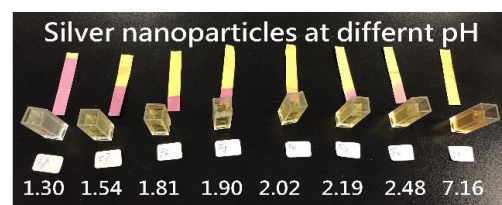


Fig. 4.6.1 Starch-stabilized AgNPs at different pH

6. Procedure of measurement of absorbance of starch-stabilized silver nanoparticles at different pH

D. The results and conclusions were as follows:

- Absorbance of 0.012M starch-stabilized AgNPs at 429nm was 0.573.
- The size of starch-stabilized AgNPs obtained using glucose as the reducing agent in a microwave at medium power for 2½ minutes was 34.6nm, which was obviously smaller than that of the non-stabilized AgNPs (249.7nm).
- Antibacterial effect of both starch-stabilized AgNPs and non-stabilized AgNPs were significant.
- Starch-stabilized AgNPs produced one month ago had a similar catalytic effect on photo-fermentation of algae compared to the freshly produced one.
- 10nM starch-stabilized AgNPs was better than the well-known photo-catalyst TiO_2 in terms of enhancing the rate of photo-fermentation of algae.
- Starch-stabilize AgNPs was found to have better photo-catalytic effect than AgNPs without starch.
- The hydrogen gas obtained from photo-fermentation of algae could reach the concentration of 100%LEL (4% or 40000ppm)

h) The complex of AgNPs and starch would be destabilized when the pH was lower than 2.48. The complex was destroyed in alkaline medium to give Ag₂O. solid

It is highly possible that weak forces are formed between the oxygen in the –OH groups of starch and AgNPs. This helps stabilizing the AgNPs. (Balavandy, 2014)

i) The photo-catalytic effect of AgNPs was still sound when the pH was between 4.48 and 7.

To sum up, starch-stabilized AgNPs can be widely used in medical service and fuel production. We hope they can be beneficial to human beings by killing lethal pathogens and help generate hydrogen gas which is a clean and renewable source of energy while promising us a sustainable future.