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Theme of Year: Chemistry of Metal

Theme metal: Silver

Project title: Preparing Silver Nanoparticles by sodium citrate

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Report

Project title: Preparing Silver Nanoparticles by sodium citrate

Objectives

Produce Silver nanoparticle that is about 15 to 30 nm large by reducing silver nitrate($AgNO_3$) to nano particles, then stable, prevent them aggregate together and become silver again.

Abstract

Silver nanoparticles can be used in cleaning, disinfecting. This report presents the combination of different chemicals with $AgNO_3$. We will do four experiments to test which combination can produce a better silver nanoparticles. We will also measure the time we needed to produce it. We will use sodium borohydride ($NaBH_4$), polyvinyl alcohol (PVA), citrate solution and water in these experiments.

Principles

Silver nanoparticles are the silver particles that are in nano size. Silver nanoparticles in the solution is yellow in color. A recent research found that silver nanoparticles can destroy the DNA or cell wall of gems and bacteria so it is used to make surgical instruments, masks and wound dressings. If the silver nanoparticles are small enough, such as 1 to 10 nm, it can prevent HIV-1 virus from bonding to host cells. It is also used to make bone cements.

Sodium borohydride is used as a reducing agent to reduce silver ions to silver nanoparticles and sodium borohydride is chose because it can form rather clear and stable silver nanoparticles than other reducing agents with silver nitrate. But it is not recommended to use because it is quite expensive and it is toxic. Also, if we want to stabilize the silver nanoparticles with just sodium borohydride, we need much more sodium borohydride than silver nitrate.
Equation of adding silver nitrate and sodium borohydride together:
$2AgNO_3 + 2NaBH_4 \rightarrow 2Ag+H_2+B_2H_6+NaNO_3$

If sodium citrate is added to silver nitrate, it can reduce silver ions to silver and later the negatively-charged citrate ions are adsorbed onto the silver nanoparticles, introducing the surface charge that repels the particles and prevents them from aggregation. It is used as electrostatic stabilization. It will generate an electrical double-layer around the silver nanoparticles. If the electric potential associated with the double layer is high enough, then the electrostatic repulsion will prevent particle aggregation. Its concentration should keep low to avoid the presence of excess citric acid in the silver suspension.
Equation of adding silver nitrate and sodium citrate together:
$AgNO_3 + C_6H_5O_7Na_3 \rightarrow Ag+$

Polyvinyl alcohol is used for steric stabilization in these experiments. The adsorption of PVA molecules at the surfaces of the silver nanoparticles will provide a protective layer. In the interparticle space, PVA will be restricted in motion, which causes a decrease in entropy and thus an increase in free energy. A second effect is due to the local increase in concentration of PVA as the two protective layers begin to interpenetrate. This result in an osmotic repulsion as the solvent will reestablish the equilibrium by diluting the PVA and thus separating the silver nanoparticles.

In this project, we will study the effect of the concentration of sodium citrate, the concentration of polyvinyl alcohol, the ratio between polyvinyl alcohol and sodium citrate and the reaction time on the reaction to form silver nanoparticles. After that, we will conclude the best method to get the best quality of silver nanoparticles.

Chemical used

Silver Nitrate, $AgNO_3$
Sodium Borohydride, $NaBH_4$
Polyvinyl alcohol (PVA), $(CH_2CHOH)n$
Sodium Citrate, $C_6H_5O_7Na_3$

Chemical Hazards

Silver nitrate is corrosive, causing burns in contact with the skin and eyes.
Sodium borohydride is flammable and toxic.
Sodium citrate and polyvinyl alcohol are irritants; avoid contact with skin and eye, ingestion and inhalation.

Apparatus and Materials used

Flat-bottomed flasks, glass rods, measuring cylinders, reagent bottles, beakers, pipettes, heater and stirrer, electric balance and droppers.

Experimental methods

Part 1: To determine the best concentration of sodium citrate
The 0.5mM silver nitrate concentration solution and 0.5mM sodium citrate solution were first prepared. Fixed volume of silver nitrate solution and different volumes of sodium citrate solution and water were mixed. The mixtures were stirred and heated until boiling for 30mins.

Part 2: To determine the concentration of PVA with NaBH4 (TOXIC)
The 0.5mM silver nitrate solution concentration and 0.2mM sodium borohydride solution was first prepared. These two solutions were mixed with different amount of prepared 1% PVA solution and water. The mixtures were stirred and heated until boiling for 40mins.

Part 3: To determine the best ratio among PVA, sodium citrate and silver nitrate

The 0.5mM silver nitrate solution concentration and 0.5mM sodium citrate solution were first prepared. These solutions together with 1% PVA solution and water of different volume were mixed. The mixtures were stirred and heated until boiling for 40mins.

Part 4: To determine the most suitable time for preparing silver nanoparticles

The same set up of the best set obtained from the part 3 of experiment was used. The time for each set was 25mins, 35mins, 45mins and 55mins.

Finally, if the reaction mixture obtain is clear yellow, the experiment is considered as successful.

Presentation and interpretation of result

Notes: Silver nanoparticles in solution states yellow in color.

Part 1: To determine the suitable concentration of sodium citrate

	Volume of 0.5mM $AgNO_3$	Volume of 0.5mM $C_6H_5O_7Na_3$	Volume of H_2O
1.	30mL	20mL	0mL
2.	30mL	10mL	10mL
3.	30mL	4mL	16mL
4.	30mL	2mL	18mL

(1) It changed from colorless to yellow and quickly changed to brown. Finally, black precipitate formed.

(2) It changed from colorless to yellow and gradually changed to clear yellow.

(3)It changed from colorless to light yellow and gradually changed to yellow. Finally, black precipitate formed.

(4)It changed from colorless to pale yellow and gradually changed to deeper yellow. Finally, black precipitate formed.

→In that experiment, sodium citrate was used to speed up the reaction and the suitable concentration of sodium citrate was obtained. After the reaction, it was known that 10ml of 0.5mM sodium citrate was enough for the anion and cation in repulsion.

Silver Nanoparticle was prepared. (Success)

Silver Nanoparticle was not prepared.(Failed)

Part 2: To determine the suitable concentration of PVA with NaBH4 (TOXIC)

	Volume of 0.2mM $NaBH_4$	Volume of 0.5mM $AgNO_3$	Volume of 1% PVA	Volume of H_2O
1.	30mL	10mL	5mL	5mL
2.	30mL	10mL	0mL	10mL
3.	30mL	10mL	10mL	0mL

(1) It changed from colorless to yellow and gradually changed to brown. Finally, black precipitate formed.

(2) It changed from colorless to brownish yellow and quickly changes to brown. Finally, black precipitate formed.

(3) It changed from colorless to pale yellow and gradually changed to clear yellow.

→In this experiment, the different concentration of PVA were used which will stabilize the nanoparticles but slow down the reaction and to find out which concentration is the most sutiable. And 10ml of 1% PVA was the most suitable.

Part 3: To determine the best ratio among PVA, sodium citrate and silver nitrate

	Volume of 0.5mM$AgNO_3$	Volume of 0.5mM $C_6H_5O_7Na_3$	Volume of 1% PVA	Volume of H_2O
1.	30mL	10mL	10mL	0mL
2.	20mL	10mL	10mL	10mL
3.	20mL	10mL	20mL	0mL
4.	20mL	20mL	10mL	0mL

(1) It changed from colorless to yellow and quickly changed to brown. Finally black precipitate formed.

(2) It changed from colorless to pale yellow and gradually changed to brownish yellow. Finally, black precipitate formed.

(3) It changed from colorless to very pale yellow and gradually changed to yellow. Finally, it changed to golden yellow.

(4) It changed from colorless to pale yellow and gradually changed to clear yellow.

→In this experiment, both citrate and PVA were used, as citrate speeded up the reaction and PVA slow down reaction. And the set 4 was the best set from the experiment, the ratio of PVA, sodium citrate and silver nitrate was 1:2:2.

Part 4: To determine the most suitable time for preparing silver nanoparticles

	Volume of 0.5mM$AgNO_3$	Volume of 0.5mM $C_6H_5O_7Na_3$	Volume of 1% PVA	Volume of H_2O	Time(min)
1.	20mL	20mL	10mL	0mL	~25
2.	20mL	20mL	10mL	0mL	~35
3.	20mL	20mL	10mL	0mL	~45
4.	20mL	20mL	10mL	0mL	~55

(1) It changed from colorless to pale yellow and gradually changed to clear yellow.
(2)It changed from colorless to yellow with a little black precipitate.
(3)It changed from colorless to dark yellow.
(4) It changed from colorless to dark yellow.
→From the part 3, the best concentration of both $AgNO_3$, citrate, PVA and H_2O were obtained. In that experiment, the most suitable time for making silver nanoparticles were determined. And the set 1(~25min) was the best set from the experiment.

Discussion

For these experiments, it was to find out the suitable concentration of chemicals to prepare the silver nanoparticle, but there were some of the errors or mistakes should be reduced.
Firstly, we should be careful that to determine the right concentration of the components, for instance, the right concentration of silver nitrate (0.5mM), citrate, 1% PVA etc. That is because if the concentrations of these things are wrong, we could get the expected result .For example: if we add too much citrate, the reaction can be very fast. So we must be very careful on the concentrations.

Also, water bath should be used to instead of using heater. It is because that we use water bath, we can control the temperature easier and as we knew that the chemical were very sensitive to the temperature. So the control of temperature is very important.

Then, distilled water should also be used to instead of using tap water. As there were a lot of impurities in the tap water, some chemical may sensible with that, for example, silver chloride (white precipitates) might appear due to the reaction of silver nitrate to the chloride ions in tap water. Therefore, distilled water should be used to avoid any impurities affect the result of the experiment.

Apart from some improvements, some further investigations can be done. After the experiment, we had prepared the silver nanoparticles .As we knew that, these silver nanoparticles have the function of killing the bacteria, therefore we can take the further investigation on whether it can function well to kill the bacteria by the silver nanoparticles we prepared.

Conclusion

After a series of experiments, the following result were obtained .

From the part 1 of experiment, 10ml of 1% sodium citrate was the most suitable.

From the part 2 of experiment, 10ml of 1% PVA was the most suitable.

From the part 3 of experiment, the ratio of PVA, sodium citrate and silver nitrate was 1:2:2 which the most suitable.

From the part 4 of experiment, the mixed solution of 20ml 0.5mM AgNO3, 20ml 0.5mM sodium citrate and 10ml 1% PVA was heated for about 25 minutes could be prepared a sharp yellow color silver nanoparticles

References

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