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**Making of Silver Nanoparticles**

**Students’ Handout**

**Objective**

* To synthesise silver nanoparticles from silver nitrate solution and sodium borohydride solution.
* To observe the properties of silver nanoparticles.

**Task**

* To synthesise silver nanoparticles from silver nitrate solution and sodium borohydride solution.
* To observe the colour of the solution of the silver nanoparticles.
* To study the aggregation of the silver nanoparticles in the solution prepared.

**Background**

Nanomaterials are organic or inorganic materials that have particle sizes below 100 nm. They are interesting because they have properties that are very different from those of the bulk materials. For example, silver is a metal. It has a silvery and metallic appearance. When dispersed in water, very fine powder of silver material looks grey. But the colour of silver nanoparticle is yellow or bright yellow. This is just one of the many interesting examples of the unique properties of nanomaterials.

In this experiment, you will prepare the silver nanoparticles by carefully mixing silver nitrate solution and excess sodium borohydride solution. In the reaction, sodium borohydride acts as a reducing agent to reduce the Ag+ ions into silver metal. Silver nanoparticles are formed first. They are then stabilised by sodium borohydride and further growing to particles with bulk size is suppressed. When these nanoparticles are allowed to aggregate to larger particles, however, properties of the nanoparticles (such as the yellow or bright yellow colour) will be lost. The changes of properties upon the aggregation of the silver nanoparticles will also be studied in this experiment.

**Curriculum Link**

Topic XIV Materials Chemistry

**Safety Precautions**

* Wear safety glasses, laboratory coats and disposable plastic gloves.
* Sodium borohydride is corrosive and toxic. It is hazardous in case of skin contact, eye contact, ingestion and inhalation. It is also flammable. Handle it with great care.
* Sodium borohydride should not be mixed with acids as sodium borohydride reacts vigorously with acids and give flammable hydrogen gas.
* Silver nitrate solution is caustic and stains skin, clothes and bench surface. Use it carefully.

**Apparatus (per group)**

* 100 cm3 Beakers × 3
* 10 cm3 Measuring cylinder × 1
* 50 cm3 Measuring cylinder × 1
* Glass rod × 1
* Burette × 1
* Magnetic stirrer bar × 1
* Electric stir plate × 1
* Ice bath × 1
* Disposable droppers × 3
* Laser pointer × 1

**Chemicals (per group):**

* 0.0010 M AgNO3(aq) 10 cm3
* 0.0020 M NaBH4 (aq) 30 cm3
* Saturated NaCl (aq) 10 cm3

**Procedure**

**Part A: Synthesis of Silver Nanoparticles**

1. Use a measuring cylinder to measure 30 cm3 of 0.0020 M sodium borohydride solution, and pour the solution into a 100 cm3 beaker. *(Note: the sodium borohydride solution must be freshly prepared immediately before the experiment session starts.)*
2. Place the beaker into an ice bath. Cool the solution in the ice bath for about 5-10 minutes.
3. Use a clean measuring cylinder to measure 10 cm3 of 0.0010 M AgNO3 solution and transfer the solution into a burette.
4. Stir the NaBH4 solution in the beaker with a magnetic stirrer bar or a glass rod.
5. With the beaker containing NaBH4 solution still in the ice bath, add the AgNO3 solution dropwise from the burette to the NaBH4 solution in the beaker with continuous stirring, at a rate of about 1 drop per second, until the silver nitrate solution is used up.
6. ***Stop the stirring as soon as the addition of silver nitrate solution is finished***, and remove the stirrer bar or glass rod from the mixture.
7. Observe the mixture and record the observations.

**Part B: Study the Properties of the Silver Nanoparticles**

1. Right after the silver nanoparticles are prepared, place the beaker containing the nanoparticles and a 100 cm3 beaker containing about 40 cm3 water side by side.
2. Turn on a laser pointer from sideway such that the laser beam goes through both the solutions in the beakers. Record the observations.
3. Transfer about half of the silver nanoparticle solution into another 100 cm3 beaker, add about 10 cm3 of saturated NaCl solution into the beaker. Observe for any change.

**Disposal and Clean-up**

1. After the experiment, dispose of the silver nanoparticle solutions into the designated chemical waste bottle.
2. Rinse the glassware with water.

**Results**

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|  | Observations |
| Appearance of the 0.0010M silver nitrate solution. |  |
| Appearance of the 0.0020 M sodium borohydride solution. |  |
| Addition of AgNO3 solution to the NaBH4 solution. |  |
| When the addition of AgNO3 solution is finished. |  |
| When the laser beam goes through the water in beaker. |  |
| When the laser beam goes through the silver nanoparticle solution in beaker. |  |
| When NaCl solution is added to the silver nanoparticle solution. |  |

**Questions**

1. What is the oxidation number of silver in (a) silver nitrate and (b) silver nanoparticles?
2. Write a half equation for Ag in the reaction.
3. What is/are the role(s) of NaBH4 in the solution?
4. State, with explanation, one important precaution when using NaBH4.
5. Is there any observed difference when a laser beam goes through the silver nanoparticle solution in beaker and water in beaker? Explain the difference(s) if any.
6. Explain why silver nanoparticles give a colour.
7. Explain why the bright yellow silver nanoparticles turn into grey precipitates when sodium chloride solution is added.