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**Making of Silver Nanoparticles**

**Teachers’ notes**

**More about the Background of the Experiment**

Plasmonic metal nanoparticles, such as gold, silver and platinum, demonstrate efficient light absorbing and scattering properties, the reason of such properties is due to the plasmon resonance. Wavelengths of light can interact with the conduction electrons in the plasmonic metal nanoparticles and so the electrons will oscillate collectively, a phenomenon known as the surface plasmon resonance (SPR). These excited resonances can increase the absorption and scattering intensities up to 40 times as compared with other non-plasmonic particles with identical size. In contrast, the interactions between electrons in pure metals of bulk size and light have more limitations and so plasmon resonance is not observed.

Both scattering and absorbance of light will affect the perceived colour. In the case of silver nanoparticles, its yellow colour is presumably due to the plasmon absorbance.

A colloid is a mixture in which one substance of microscopic insoluble particles is dispersed uniformly throughout another substance. In this experiment, a colloid is formed in which insoluble silver nanoparticles are dispersed uniformly throughout the solution.

Silver nanoparticles are stabilised by the adsorption of borohydride ions. Each silver nanoparticle is surrounded by negatively charged borohydride ions, the repulsive electrostatic forces between the particles owing to adsorbed borohydride ions make the silver nanoparticles unable to aggregate, and so they stay apart:



**Preparations of solutions:**

1. **1000 cm3 of 0.0020 M NaBH4(aq):** Weigh 0.076 g of NaBH4(s) and dissolve it in deionised water to volume in a 1000 cm3 volumetric flask.
2. **1000 cm3 0.0010 M AgNO3(aq):** Weigh 0.17 g of AgNO3(s) and dissolve it in deionised water to volume in a 1000 cm3 volumetric flask.
3. **200 cm3 of saturated NaCl(aq):** Add excess amounts of NaCl(s) into 200 cm3 of deionised water.

***Note:*** *the sodium borohydride solution must be freshly prepared before the experiment session starts.*

**Disposal and Clean-up**

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

**Sample Results**

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|  | Observations |
| Appearance of the 0.0010M silver nitrate solution. | Colourless solution |
| Appearance of the 0.0020 M sodium borohydride solution. | Colourless solution |
| Addition of AgNO3 solution to the NaBH4 solution. | Bright yellow colloid (nanoparticles) begins to form. |
| When the addition of AgNO3 solution is finished. | Bright yellow colloid (nanoparticles) is observed. |
| When the laser beam goes through the water in beaker. | The light beam passes through the solution without any scattering observed. (The light path cannot be seen.) |
| When the laser beam goes through the silver nanoparticle solution in beaker. | The light is scattered by the nanoparticles in the solution. (The light path can be seen in the colloid.) |
| When NaCl solution is added to the silver nanoparticle solution. | The bright yellow silver colloid (nanoparticles) aggregates to form grey silver precipitates. |

**Questions**

1. What is the oxidation number of silver in (a) silver nitrate and (b) silver nanoparticles?

(a) +1; (b) 0

1. Write a half equation for Ag in the reaction.



1. What is/are the role(s) of NaBH4 in the solution?

Reducing agent and stabilising agent.

1. State, with explanation, one important precaution when using NaBH4.

NaBH4 is highly hygroscopic. It should be kept in a tightly closed desiccator, and should be kept away from moisture, or,

NaBH4 reacts vigorously with acids to give flammable hydrogen gas. So NaBH4 should be kept away from acids.

1. 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.

Silver nanoparticles in solution give a colloid. The light is scattered when shining on the colloid, showing the path of light.

For pure water, there are no particles inside the liquid to scatter the light, so the path of light is not observed.

1. Explain why silver nanoparticles give a colour.

Nanoparticles can absorb part of the spectrum of white light. The unabsorbed portion is the colour of the nanoparticles.

1. Explain why the bright yellow silver nanoparticles turn into grey precipitates when sodium chloride solution is added.

The sodium chloride promotes the aggregation of silver nanoparticles to form particles of larger sizes. As the particle sizes getting larger, the special properties of nanoparticles (such as the ability to absorb part of the spectrum of white light) are lost. Finally, the aggregated particles behave like normal particles.

**Notes for Teachers about the Experimental Procedure**

1. Sodium borohydride is highly hygroscopic. It must be kept carefully in a desiccator and should be handled with care.
2. Sodium borohydride reacts with water very slowly. The sodium borohydride solution should be freshly prepared before the experiment session.
3. Cooling the NaBH4 solution in an ice bath when adding AgNO3 solution can effectively prevent the aggregation of the silver nanoparticles. Better experimental results can be obtained if the solution is carefully kept at low temperature.
4. The rate of adding AgNO3 solution to NaBH4 solution is critical to the formation of the silver nanoparticles. Adding the AgNO3 solution too fast may promote the aggregation of the silver nanoparticles.
5. Instead of using a burette to add the AgNO3 solution, the solution can be added to the mixture slowly with a dropper.
6. When silver nanoparticles are present in a solution, a colloid is formed. When a light beam (from a flashlight or a laser pointer) passes through the colloid, the light is scattered by the colloidal particles/nanoparticles and the path of light can be observed.
7. When a light beam passes through a clear solution/liquid, such as water or sodium chloride solution, there is no scattering of the light and the path of light cannot be observed.
8. The aggregation of the silver nanoparticles is greatly promoted when sodium chloride solution is added into the mixture, because sodium chloride shields the charges allowing the particles to clump to form aggregates.