Gold Nanoparticles Lab

Objectives:

- To make gold nanoparticles
- To make high school students more aware of nanotechnology
- To use scientific notation and metric conversions

Background:

With the growing interest in nanotechnology, it is important to understand the metric prefix, nano- and to be exposed to a simple method called aggregation used to make nanoparticles. One nanometer is 10^{-9} meters or you can say there are 10^{9} nanometers in one meter. A nanometer is so small 1 human hair is about 50,000 nanometers across. We will not be able to see the nanoparticles because they are so small, but we will see a color change that lets us know they are forming. The color of the nanoparticle solution depends on the size and shape of the nanoparticle being formed. In this lab you will mix a gold solution with a sodium citrate solution. The mixture will change from colorless to blue to red as the nanoparticles are produced and aggregated (clumped together).

Procedure:

1. Obtain a vial of 1.0 mM $HAuCl_4$ solution from your teacher. This vial contains ~ 20 ml of solution.
2. Pour the contents of this vial into a 50 ml Erlenmeyer flask.
3. Place the Erlenmeyer flask on a hot place and heat to boiling. Stir while the solution is heating.
4. Obtain a vial of 38.8 nM $Na_3C_6H_5O_7$ solution from your teacher and use a 10 ml graduated cylinder to measure out 2 ml of the 38.8 mM $Na_3C_6H_5O_7$ solution.
5. After the $HAuCl_4$ solution begins to boil, add the 2 ml of $Na_3C_6H_5O_7$ solution.
6. Continue to boil and stir the solution until a deep red color appears. This takes about 10 minutes.
7. Turn off the hot plate and allow the solution to cool to room temperature.
8. Label your vial with your names and pour the nanoparticles into your labeled vial.
9. Bring your vial of gold nanoparticles to the teacher and shine a laser pointer through your nanoparticles. The solution is a colloidal suspension so the laser beam should be reflected by the gold nanoparticles.

Observations: Record all observations here.

Questions: Answer these questions and turn this sheet in to your teacher.

1. Express the following in proper scientific notation. Show your work!
   a. 1.0 mM $HAuCl_4$ = _____ M $HAuCl_4$

   b. 38.8 mM $Na_3C_6H_5O_7$ = _____ M $Na_3C_6H_5O_7$

2. Express the diameter of a human hair in scientific notation and in units of nanometers. Convert this answer to units of meters.

3. What did you observe during this lab to suggest that a chemical change is taking place?

4. How do you know that the resulting solution is a colloidal solution?

Teacher Notes:

1. Prepare the solutions according the following directions. The amounts given will prepare enough solution for 8 lab groups. Increase or decrease the amounts to suit your needs.
    - Prepare 160 ml of 1.0 mM $HAuCl_4$ solution by dissolving g of $HAuCl_4$ in 160 ml of distilled water. Equally distribute this solution into 8 vials that are large enough to hold 20 ml of solution. This solution is unstable and keeps only a few days, so make it fresh for the lab.
    - Prepare 25 ml of 38.8 mM $Na_3C_6H_5O_7$ solution by dissolving 0.25 g of $Na_3C_6H_5O_7$ in 25 ml of distilled water.
2. The nanoparticles can be stored and used during the unit on light to show that the red solutions absorbs green light with a wavelength of ___.
3. The nanoparticles can also be used to show the difference on behaviors for an ionic and a molecular compound. Follow this procedure:
    - Prepare a 1 M solution of NaCl by dissolving 0.5 g of NaCl in 10 ml of distilled water
    - Prepare a 1 M solution of sugar by dissolving 2g of sugar in 10 ml of distilled water.
    - Have students measure 3 ml of their nanoparticles and place it in a small vial. Label this vial as NaCl (ionic compound)
    - Have students measure 3 ml of the nanoparticles and place them in another vial. Label this vial as sugar (molecular compound)
    - Add 5 – 10 drops of the NaCl solution one drop at a time to the vial marked as NaCl. Record any color changes observed.
    - Add 5 – 10 drops of the sugar solution one drop at a time to the vial marked sugar. Record any color changes observed.

    The ionic NaCl solution should cause the gold nanoparticles to aggregate and the solution will change from red → blue. The sugar solution should not show a color change because there are no ions available to aggregate the charged gold nanoparticles.