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Abstract:

“Nano” is everywhere these days! When you check the newspaper, surf the web, even watch sci-fi movies, you see nanotechnology. The control of materials on the nanometer scale is definitely the center of many different research directions. The definition of nanoscience is the study of phenomena associated with and the manipulation of materials that are with at least one dimension between 1 and 100nm in size. Nanoscience has attracted a great deal of attention recently due to the fact that oftentimes the properties of these “really small” materials differ significantly from those of their macroscopic analogues which we are accustomed to. But nanoscience is not new. Gold and silver nanoparticles have been used by European ancients as colored pigments in stained glass and ceramics since the 10th century AD. Even the first scientific research on gold nanoparticles was performed 150 years ago by Michael Faraday. However, the pioneering work on modern nanoscience is generally ascribed to Richard Feynman’s “there’s plenty of room at the bottom” lecture on December 29th 1959. The potential of nanoscience was clearly presented in the lecture. Then, through the invention and quick development of electronic imaging techniques from the 1980’s, our ability to examine materials at the nanoscale progressed. This outreach program focuses on the science behind the “hype.” We will revisit the origins of the field and spotlight the state-of-art nanoscience researches in different research fields. The teaching material can be used in high school science courses. This program will also demonstrate an easy method for preparing nanoparticles that can be used in high school courses. We aim at synthesizing magnetic nanoparticles. In the past decades, magnetic nanoparticles have been intensively studied for many technological applications: magnetic storage media, biosensing applications, targeted drug delivery, contrast agents in magnetic resonance imaging (MRI), and magnetic inks for jet printing. The nanoparticles can be prepared in less than 2 h. The synthesis is based on reacting iron(II) and iron(III) ions in an aqueous ammonia solution to form magnetite nanoparticles. The magnetite is mixed with aqueous solution with surfactants, which can surround the nanoparticles to create electrostatic inter-particle repulsion in an aqueous environment. This method demonstrates the basic principles of nanomaterials and the general synthetic strategies. We also include several dramatic classroom demonstrations of the attraction of the magnetic nanoparticles.

Synthesis of Iron Oxide Nanoparticle

Chemicals and materials required:

-iron (II) chloride tetrahydrate (s)

-iron (III) chloride (s)

-concentrated ammonium hydroxide (aq) (ammonia)

-tetramethylammonium hydroxide (l)

-deionized or distilled water

-a strong magnet and magnetic stir bar remover

-2x 600 mL beakers

-small and large graduated cylinder

-plastic pipettes

-a weigh boat

-spray bottle with DI water

-petri dishes (for storage)

-waste container

Preparation of stock aqueous solutions:

1. To prepare a 2.0 M iron (II) chloride ($FeCl_2$) solution, add 4.0 g $FeCl_2 \cdot 4H_2O$ to 10 mL DI water.
2. To prepare a solution which is 1.0 M in iron (III) chloride ($FeCl_3$), add 4.0 g $FeCl_3$ to 25 mL DI water. Then add 8 mL concentrated hydrochloric acid to the solution.
3. The 1.0 M solution of ammonia (NH_3) is prepared by adding 60 mL of concentrated ammonium hydroxide (NH_4OH) solution to 940 mL DI water.

Fe_2O_3 nanoparticle ferrofluid synthesis:

1. Add 5.0 mL of 2.0 M $FeCl_2$ stock solution (using a graduated cylinder) to a 600 mL beaker on a stir plate (use a stir bar to generate a nice vortex).
2. Add 25 mL of 1.0 M $FeCl_3$ stock solution to the beaker in the same manner.
3. Slowly add 250 mL of 1.0 M NH_3 stock solution to the beaker by adding the amount using a plastic pipette at the rate of approximately 50 mL per minute (~one large squirt of ammonia per sec). It should take about 5-6 minutes to complete.
4. Once the last drops have been added, turn off the stir plate, quickly remove the stir bar (with a stir bar remover) and remove the excess ammonia by drawing the magnetic particles to the side of the beaker with a strong magnet (decant the supernatant into a designated waste container).
5. Repeat this cleaning and separation process 2-3 times by removing the magnet and redispersing the black solid in water (several squirts/mLs of water may be necessary) and again drawing the particles to the side with the magnet.
6. Once the particles are clean and most of the water is removed with the separation technique, add 5 mL of tetramethylammonium hydroxide solution while simultaneously stirring with the bulb of a plastic pipette. Perform a final rinse and separation.
7. Investigate the magnetic properties of the iron oxide ferrofluid using a strong magnet.
8. Store the ferrofluid in a covered petri dish in the lab for later use (keeps ferrofluid from solidifying).