NANOTECHNOLOGY EXPERIMENTS FOR GENERAL CHEMISTRY LABORATORY CLASSES

David A. Katz
Department of Chemistry
Pima Community College
Tucson, Arizona, U.S.A.
Email: dkatz@pima.edu
Web site: http://www.chymist.com
• Nanotechnology
  – Major area of research and development
  – Only now being included in recent editions of textbooks for general chemistry
  – Almost no inclusion in the student laboratory.

• Lab procedures and kits developed at the Materials Research Science and Engineering Center (MRSEC) at the University of Wisconsin-Madison [http://mrsec.wisc.edu/Edetc/index.html](http://mrsec.wisc.edu/Edetc/index.html) (Go to video lab manual)
Courses

CHM 121IN, Chemistry and Society

CHM 125IN, Consumer Chemistry
  Non-major courses
  Taught as a hands-on learning courses
  Experiments introduced in 2003

CHM 151-152IN, General Chemistry

ENG 110IN, Solid State Chemistry
  LED and solar cell experiments included in laboratory
Mood Rings

Dark blue: Happy, romantic or passionate
Blue: Calm or relaxed
Blue-green: Somewhat relaxed
Green: Normal or average
Amber: A little nervous or anxious
Gray: Very nervous or anxious
Black: Stressed, tense or feeling harried
Liquid Crystals

Both pressure sensitive and temperature sensitive (thermochromic) mixtures are prepared
Liquid Crystals

- Organic compounds in a state between liquid and solid
- Viscous, jelly-like materials that resemble liquids in viscosity and crystals in lightscattering and reflection
- Highly anisotropic (having different optical properties in different directions) - usually long and narrow - and revert to an isotropic liquid (same optical properties in all directions) through thermal action (heat) or by the influence of a solvent.
Cholesterol
Cholesteryl Ester Liquid Crystals
Types of Cholesteryl Liquid Crystals

**Lyotropic**
Molecules consist of a nonpolar hydrocarbon chain with a polar head group. In a solvent, such as water, the water molecules are sandwiched between the polar heads of adjacent layers while the hydrocarbon tails lie in a nonpolar environment.

These tend to be pressure and temperature sensitive
Types of Cholesteryl Liquid Crystals

**Smectic**
Molecules arranged in horizontal layers or strata and are standing on end either vertically or at a tilt.

**Nematic**
Molecules possess a high degree of long-range order with their long axes approximately parallel, but without the distinct layers of the smectic crystals.

These are temperature sensitive
Cholesteryl Ester Liquid Crystals

Mix liquid crystal materials

Melt the material

Allow to cool
Temperature Transition of a Mood Ring  (Coming soon)

**Dark blue:** Happy, romantic or passionate

**Blue:** Calm or relaxed

**Blue-green:** Somewhat relaxed

**Green:** Normal or average

**Amber:** A little nervous or anxious

**Gray:** Very nervous or anxious

**Black:** Stressed, tense or feeling harried
Investigation of an LCD watch display

- Take watch apart
- View with polarizer
- Remove electronics and display
- Display is touch sensitive
- Determine transition temperature
- Cut and rotate part of top polarizer
Liquid Crystal “Pixel”

Uses 4’-pentyl-4-biphenyl-carbonitrile
Liquid Crystal “Pixel”
(Still working out some “kinks”)

1. Prepare polyvinylalcohol solution
2. Coat conductive glass
3. Wipe surface
4. Clean edge
5. Prepared glass plate
6. Plastic film spacers
7. Clamp together
8. Add 4′-pentyl-4-biphenyl-carbonitrile to “pixel”
9. Add polarizing filter
10. Attach 9-V battery.
11. Finished “pixel”
Titanium Dioxide Raspberry Solar Cell

Grind nanocrystalline TiO$_2$ with dilute acetic acid

Coat surface conducting glass

Bake coating on hot plate

Dip into berry juice

Rinse

Coat 2nd piece of glass with carbon

Clamp together

Dope with KI$_3$ solution

Measure voltage
Aqueous Ferrofluid

- Colloidal suspensions of magnetic nanoparticles.
- Responds to an external magnetic field.
- Fe₂O₃ magnetite nanoparticles can be produced by mixing Fe(II) and Fe(III) salts together in a basic solution.
- Surfactants are used to prevent the nanoparticles from approaching one another too closely.
- Ferrofluids exhibit “spikes” when placed in the proximity of a strong magnet.
Aqueous Ferrofluid

Mix FeCl₂ and FeCl₃

React with aqueous NH₃

Decant liquid and transfer solid to a weighing boat

Rinse with water and tetramethylammonium hydroxide

Place a magnet under the ferrofluid.

Store in 70% 2-propanol
LED’s

Experiments:
• Observe diode behavior
• Determine relative wavelength of light
• Determine relative energies of different colored LED’s
• Measure voltages
• Control light path with an optical fiber
• Apply LED light to a luminescent material
Nitinol

- Explore properties.
- Train wire into spiral shape

Heat water and Nitinol wire "zips" back to its original shape at a "characteristic" temperature.

Austenite

Heat Recovery

Cooling

Deform

Cold Martensite

Cold Martensite
Nitinol

The Thermobile, a nitinol motor

A Nitinol butterfly
Training Nitinol Wire

Obtain a wire bending plate
This is a Beadalon Thing-a-ma-Jig

Fasten Nitinol wire in place with stainless steel screws and washers

Heat with a mini blow torch
Graphene  (Coming soon)

Transfer graphite to Scotch tape

Peel layers apart

Transfer to a silicon wafer

View under a microscope (lots of debris)
Sources

Cholesteryl liquid crystals: Sigma-Aldrich Chemical Co.
Nanocrystalline titanium dioxide solar cell kit: ICE – Univ. of Wisconsin (get one kit only)
Aqueous Ferrofluid: Flinn Scientific and Sigma-Aldrich
LED Color Strip Kit: ICE-Univ. of Wisconsin (get one kit only – additional materials from an electronics store)
Nitinol wire: Images Scientific Instruments
Nitinol Butterfly: Images Scientific Instruments
Beadalon wire bending plate: Craft store or Amazon.com
Mini-torch: Harbor Freight Tools
Web sites:

http://www.chymist.com
   Click on Laboratory Experiments on left-hand menu.

Materials Research Science and Engineering Center (MRSEC) at the University of Wisconsin-Madison
http://mrsec.wisc.edu/Edetc/index.html
   Go to video lab manual

Note: See The Nano Song
http://www.youtube.com/watch?v=LFoC-uxRqCg