WAYNE STATE UNIVERSITY

STEM Day Lesson Plan

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Title: Liquid Crystals: The Chemistry Behind Mood Rings and iPhone Screens

Subject Area: Chemistry; Physics; Materials Science

Learning Activity Description: Students will use liquid crystal temperature sensors to "image" hidden objects and those not visible to the naked eye, and brainstorm ways to use the sensors for applications.

Lesson Activity Objective: Students often perceive technology as "mysterious" or "magical", and therefore "unknowable". This activity ties basic principles in chemistry, physics, and materials science to the function of the ubiquitous liquid crystal display (LCD). Students then demonstrate this knowledge to envision new uses for liquid crystal sensors.

Lesson Activity Outcomes: Students will describe how liquid crystals change their pitch as a function of temperature and correlate observed color to pitch, and consequently to temperature. Students will decipher secret items hidden in envelopes by using liquid crystals to monitor their thermal characteristics. Finally, students will come up with an invention for liquid crystal sensors.

Materials/Supplies Listed:

- Powerpoint slides describing liquid crystals and their operation (examples can be found at https://archive.education.mrsec.wisc.edu/IPSE/educators/lcSensors.html)
- Create kits comprising:
    - Instructions
        -
    - 4 x 6" sheet of liquid crystal
    - 1-2 disposable hand warmers (little hotties)
    - 3 envelopes containing hidden items with clues on the outside
        - Examples may include keys, coins, and refrigerator magnets cut into specific shapes
- Assorted mood rings for the students to take home so they can "share" their knowledge of liquid crystals with friends and family.

Teacher Procedures:

1. Using the powerpoint slides, give an interactive presentation on materials, nano and liquid crystals, focusing on how the pitch of liquid crystals changes with temperature. (10-15 minutes)
2. Have students break into groups of 2-4 and give each group a kit.

3. Instruct the students to use the liquid crystal sheets to image the latent heat of handprints, focusing on how the colors fade upon cooling. Does this correlate to what was predicted based on liquid crystal pitch? (5 minutes)
4. Use your hands or the little hotties to warm up the items in envelopes and then image these with the liquid crystal sheets to solve the clues. (5 minutes)
5. Informing the students that some liquid crystals can sense movement, pressure, chemicals, biological agents and electricity, ask them to brainstorm inventions that could use these sensors. For example, it might be good to have road signs that say "Watch out for ice" when the temperature drops below freezing and plates that say "Clean me" when bacteria or dirt are present. The students should sketch or describe their invention on the provided sheet. (10 minutes)
6. In a round-robin fashion, the groups should perform 1 minute "elevator pitches" of their ideas to the rest of the group.
7. Upon departure, give the students a mood ring to take home. Ask them if they really think they tell their "mood" and encourage them to share what they learned.

Preparation Time for Learning Activity: Approximately 5 minutes to make each re-usable kit and 10 minutes to set up the room.

Room set-up:
Projector to show slides (or posterboard, with printed slides)
Tables and chairs for students to perform the hands on activity

Group Strategies (example, group size, expected time for groups, etc.): Students will work in groups of 2-4.

Student Products/Artifacts/work pages: see attached

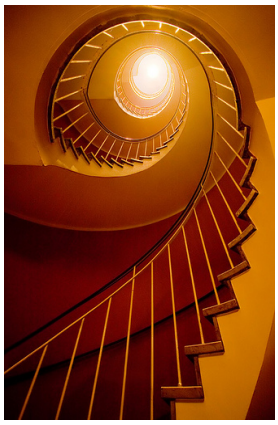
Assessment Criteria/Rubric: Responses to the three questions on the work page; Elevator pitches at the end, describing sensing invention.

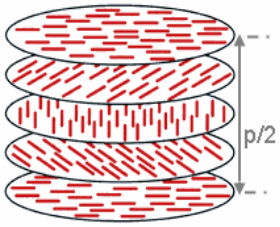
Closing/Transition to next activity: N/A

Note that this activity is based upon a "Liquid Crystal Sensors" module developed by the University of Wisconsin-Madison MRSEC education group. More information can be found at:https://archive.education.mrsec.wisc.edu/IPSE/educators/lcSensors.html

Liquid Crystal Temperature Sensors

Two properties of liquid crystals make them ideal sensors. The first is their sensitivity to changes in their surroundings (causing changes in pitch for helically-arranged liquid crystals). The second is their visual effects; they change color when they sense a change (due to interaction of light with helix). Because of these properties, we can use liquid crystal sensors to "see" what our eyes can't!

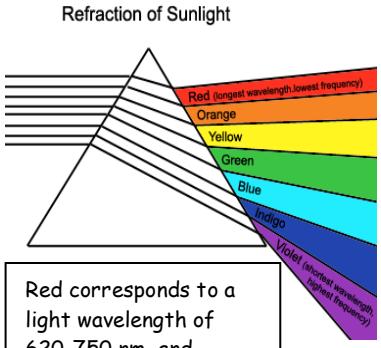




A spiral staircase (left) has a pitch. The pitch in a Nematic LC is the distance needed for the molecules to re-align (top)

Directions:

1. Place your hand on the tabletop to give some warmth from your fingers and palm to the table. Keep your hand still while doing this. Remove your hand. Look closely. Can you see a handprint on the table with your eyes? Place a liquid crystal sensor on top of your invisible handprint. Can you see your handprint now?



Red corresponds to a light wavelength of 620-750 nm, and Violet to 380-450 nm, where a nanometer is one billionth of a meter

2. What was the order of color change on cooling and how does it compare to the order of color in the "Refraction of Sunlight" image? Since the wavelength of light seen is related to the pitch of nematic liquid crystal (the distance for one complete spiral), does the pitch increase or decrease when cooling?

3. Use your hands or the little hotties to warm up the items in the envelopes and then image these with the liquid crystal sheets. Using the "clues" printed on the envelope as a guide, what are the hidden objects?

4. Just as some liquid crystal sensors can measure temperature, others can sense movement and pressure, chemicals (e.g., pollution, poisons), biological agents (e.g., viruses, bacteria), and electricity. With your group, brainstorm some potential inventions that would use liquid crystal sensors. Write your ideas the sheet back. For example, it might be good to have road signs that say "Watch out for ice" when the temperature drops below freezing and plates that say "Clean me" when bacteria or dirt are present. Prepare a 1 minute "elevator pitch" on your group's idea and deliver it to the rest of the groups, as if to a group of investors.

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