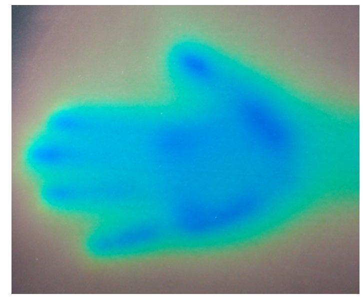
Exploring Materials—Liquid Crystals

Try this!

1. Place your hand on the tabletop to warm the surface.
2. Remove your hand. Can you see a handprint?
3. Place the large liquid crystal sheet on the table, in the spot where your hand was. Now can you see a handprint?

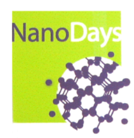



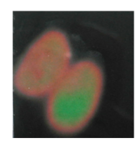
What's going on?

The liquid crystal sheet is temperature sensitive, and can detect where your hand warmed the table!

Make a liquid crystal sensor!

1. Put a sticker over the black square of a card.
2. Use a paintbrush to spread a thin layer of liquid crystal mixture on top of the sticker.
3. Carefully place the card face down onto the clear side of a self-laminating pouch.
4. Remove the paper on the other side of the pouch and seal it.
5. Warm the card with your hands. Can you get the liquid crystal to change colors?
6. Now cool it against a cool surface. What colors does it turn?



Why does it work?

Liquid crystals represent a phase in between liquid and solid. The molecules in a liquid crystal can move independently, as in a liquid, but remain somewhat organized, as in a crystal (solid).

These liquid crystals respond to changes in temperature by changing color. As the temperature increases, their color changes from red to orange, yellow, green, blue, and purple.

How is this nano?

Laptop with liquid crystal display

The way a material behaves on the macroscale is affected by its structure on the nanoscale. Changes to a material's molecular structure are too small to see directly, but we can sometimes observe corresponding changes in a material's properties. The liquid crystals in this activity change color as a result of nanoscale shifts in the arrangement of their molecules.

Nanotechnology takes advantage of special properties at the nanoscale to create new materials and devices. Liquid crystals are used in cell phone displays, laptop computer screens, and strip thermometers. They're also being used to create nanosensors—tiny, super-sensitive devices that react to changes in their environment.

Learning objectives

1. The way a material behaves on the macroscale is affected by its structure on the nanoscale.
2. The liquid crystals in this activity change color as a result of nanoscale shifts in the arrangement of their molecules.

Materials

- Liquid crystal sheet
- Vial of liquid crystal mixture
- Paint brushes
- Printed cards with black squares
- Stickers
- Self-laminating pouches
- Safety glasses
- Material Safety Data Sheets (MSDS) (3)

Liquid crystal sheets are available from www.teachersource.com (#LC-2530A, 25-30˚C transition).

Instructions for preparing the liquid crystal mixture (26.5-30.5°C transition) are available at mrsec.wisc.edu/Edetc/nanolab/LC_prep/index.html.

Chemicals can be ordered from www.sigmaaldrich.com/technical-service-home/product-catalog.html (cholesteryl oleyl carbonate #151157, cholesteryl pelargonate #C78801, and cholesteryl benzoate #C75802).

Self-laminating business card pouches are available at office supply stores (Scotch/3M #LS851G).

The card template can be downloaded from (www.nisenet.org/catalog/programs/exploring-liquid-crystals). They print on perforated business card sheets (10 per sheet, 2"x 3.5"), from office supply stores.

Clear stickers are available from onlinelables.com (#OL6300). You can substitute squares of packing tape.

Notes to the presenter

SAFETY: Visitors must be supervised when doing this activity. They must wear safety glasses to protect their eyes. Before doing this activity, read through the Material Safety Data Sheets.

The liquid crystal mixture must be viscous in order to do this activity. If it has thickened, use a hair dryer or heat gun (on a low setting) to warm the vial until the mixture is the consistency of honey.

The transition range for the liquid crystal mixture is 26.5-30.5°C. If you have difficulty seeing a reaction in the sensor, try cooling the liquid crystal against a cool surface and then warming it with your hands.

Related educational resources

The NISE Network online catalog (www.nisenet.org/catalog) contains additional resources to introduce visitors to nanomaterials:

- Public programs include *Nanoparticle Stained Glass* and *World of Carbon Nanotubes*.
- Exhibits include *Quantum Dots.*

NanoDays

Liquid Crystals Background Information

What are liquid crystals?

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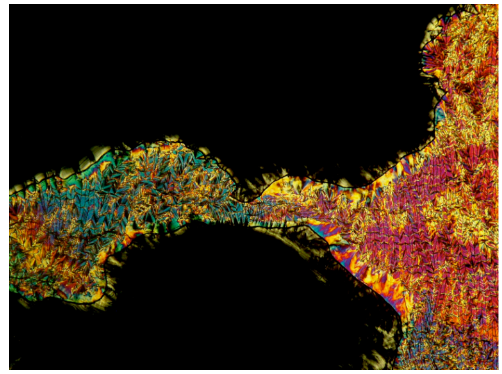


Liquid crystal

Why do the colors change?

The liquid crystals used in this activity are *thermotropic,* which means that they respond to changes in temperature by changing color. As the temperature increases, the color of the liquid crystal changes from red to orange, yellow, green, blue, and purple.

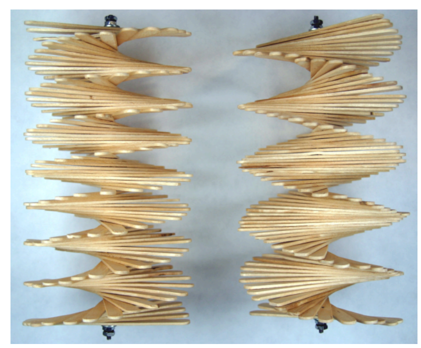
The liquid crystals in this activity are made of mixtures of long, thin molecules stacked in rotating layers, like a spiral staircase (helix).

When light strikes a liquid crystal, some of the light is reflected. The color of the reflected light depends on how tightly twisted the helix is.

More tightly twisted helixes (like the model on the left) reflect wavelengths on the blue end of the spectrum.

More loosely twisted helixes (like the model on the right) reflect wavelengths on the red end.

As the temperature of the liquid crystal changes, the spacing of the helix changes. This changes the wavelength of light that is reflected and the color that you see.



Models of liquid crystals

How are liquid crystals used?

Cell phone with liquid crystal display

The properties of liquid crystals make them useful for many applications. Because the color of a liquid crystal depends on the alignment of its molecules, anything that disrupts that alignment can be detected by a color change.

Liquid crystals are used in displays for cell phones, laptop computers, and other electronics. In these displays, an electric field changes the alignment of the liquid crystal molecules and affects the polarization of light passing through them. Liquid crystal nanosensors can detect certain chemicals, electrical fields, and changes in temperature.

Credits and rights

This activity was adapted from “Preparation of a Cholesteryl Ester Liquid Crystal Thermometer,” developed by the National Science Foundation-supported Materials Research Science and Engineering Center (MRSEC) on Nanostructured Interfaces at the University of Wisconsin-Madison. The original activity is available at mrsec.wisc.edu/Edetc/nanolab/LC_prep/index2.html.

Image of liquid crystal courtesy Gary Koeing, University of Wisconsin-Madison.

Photo of models of twisted nematic liquid crystals is courtesy of the Materials Research Science and Engineering Center (MRSEC) on Nanostructured Interfaces at the University of Wisconsin-Madison, and is by George Lisensky of Beloit College.

This project was supported by the National Science Foundation under Grant No. ESI-0532536.

Any opinions, findings, and conclusions or recommendations expressed in this program are those of the author and do not necessarily reflect the views of the Foundation.