

# Kaleidoscopic Activity

## Structures of Organic Compounds

### Introduction

A radially polarized filter is placed on an overhead projector stage and a regular (parallel) polarized filter is positioned above it. As expected, the image shows four quadrants, alternating light-dark-light-dark. When an optically active solution (corn syrup) is poured between them, the image rotates and separates into a beautiful array of spectrum colors.

### Concepts

- Chiral compounds
- Enantiomers and optical isomerism
- Plane polarization of light

### Materials

Polarized material, 2 pieces  
one approx. 4" × 12", (remove protective covering before use)  
another approx. 6" × 6" (remove protective covering before use)

Polarized filter pattern

Beaker, tall-form, 600-mL

Corn syrup

Overhead projector

Scissors

Tape, clear

### Safety Precautions

*This demonstration is considered nonhazardous. Please follow all laboratory safety guidelines.*

### Preparation

1. Use the polarized filter pattern to cut the rectangular filter into 24 sharp wedges—isosceles triangles with altitudes all running parallel to one another. Figure 1 shows the template for cutting the wedges, but the specifications are not critical. The more wedges made, the more acute each one must be; the top angle, of course, should approximate  $360^\circ/n$ , where  $n$  is the total number of wedges cut.
2. Rearrange the wedges into a pie configuration and tape them together with Magic Tape™ or a similar invisible tape. It's easiest to first place one wedge at  $0^\circ$ ,  $90^\circ$ ,  $180^\circ$ , and  $270^\circ$ , and fill in the spaces between these four. Be aware that there will be a small space between adjacent wedges: this will not be a problem.

### Procedure

1. Turn the overhead projector on, place the radially polarized filter directly on the stage, and show the spoke-like configuration of the wedges.
2. Hang the 6" × 6" polarized filter over the lens that directs the light onto the screen (see Figure 2).
3. Center a 600-mL tall-form beaker on top of the radial filter, and gradually add the corn syrup. Observe the spectrum created on the overhead image.

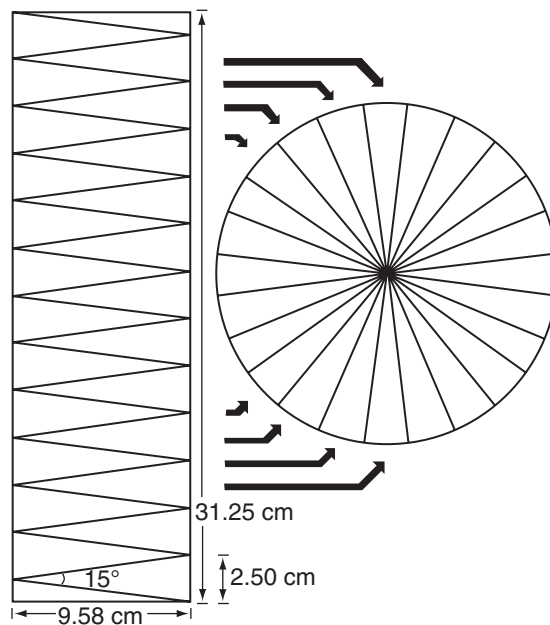


Figure 1.

## Disposal

The corn syrup can be flushed down the sink with excess water according to Flinn Suggested Disposal Method #26b. The polarizing filters can be stored and reused.

## Tips

- Use a paper cutter to cut the wedges. If they don't fit perfectly into a pie pattern, trim a few of the angles down.
- Use a piece of cardboard with a large hole cut in the center to block out any peripheral light.
- You may wish to use a colored filter (such as red) the first time you demonstrate this effect, so that the focus is solely on the rotation. Then repeat without the filter to demonstrate how different wavelengths have different rates of rotation.

## Discussion

The bright bow-tie image on the screen appears to rotate as the corn syrup is added. That is, each wedge's image becomes progressively brighter and then darker in sequence around the circle as the plane polarized light passing through the wedge is brought into and then past parallel alignment with the regular polarized filter above it. Furthermore, the leading edge of the rotating image turns red, and the trailing edge turns violet. At a corn syrup depth of 6–8 cm, with the bright bow-tie image rotated approximately 90°, the entire spectrum of colors is clearly visible two-fold around the circular image—a beautiful kaleidoscopic display.

Why are the colors present and why do they rotate? As light passes through the first polarizing filter (the circle of wedges), the light is polarized so that only light in a single plane passes through. This light, though now plane-polarized, still contains all of the component colors or wavelengths of visible light. As this light passes through the optically active solution (the corn syrup), each wavelength of light is bent to a different degree. This is very similar to the refraction of light passing through a prism. All of this plane-polarized light, now separated into its various wavelengths (each with a slightly different plane-polarized angle), now passes through the second polarizing filter. Only one plane (and therefore only one wavelength) of polarized light may pass through the filter. Because the various wavelengths of light that pass through the polarizing filter wedges were bent to different plane angles, just one wavelength from each wedge is able to pass through the second filter, and a rainbow of colors appears.

When a molecule contains a carbon atom bonded tetrahedrally to four different atoms or groups, (also known as *chiral* carbon), then two different versions of that molecule exist. These versions are mirror images of one another, but they are not the same—that is, they are not superimposable. They represent a special type of isomers known as optical isomers (or enantiomers).

These molecules have the unusual property of being able to twist light waves passing by them: one isomer (the *dextro-rotatory* isomer, designated D-) twists clockwise; its mirror-image isomer (the *levorotatory* isomer, designated L-) twists the light counter-clockwise. Solutions containing such D- or L- molecules are said to be “optically active”.

The degree to which light is rotated as it passes through such a solution depends on several factors: the specific enantiomer, its concentration, the percentage of D- and L- isomers present (if there are equal numbers of D- and L- isomer, the light will not rotate one way or the other), the distance through the solution that the light is traveling, and the frequency of the specific light waves.

Regular light is comprised of waves of all different orientations, and so it is impossible to tell when it is rotated. This light-rotating effect is only detectable when using polarized light (light with only one orientation).

## Connecting to the National Standards

This laboratory activity relates to the following National Science Education Standards (1996):

**Unifying Concepts and Processes: Grades K–12**

Evidence, models, and explanation

**Content Standards: Grades 5–8**

Content Standard B: Physical Science, properties and changes of properties in matter, transfer of energy

**Content Standards: Grades 9–12**

Content Standard B: Physical Science, structure and properties of matter, interactions of energy and matter

## Answers to Worksheet Questions

1. Describe what happened in this demonstration.

*An overhead projector was set up with a circle of polarized filter wedges. When the projector was turned on, an image appeared on the overhead screen of four quadrants in a circle, alternating light-dark-light-dark. Then, the circle of wedges was suspended over the projector, and corn syrup was poured into a beaker on the projector stage. On the screen, a circular spectrum of colors appeared that rotated as the corn syrup was poured.*

2. What was the function of the polarized filter material?

*The material polarized the light as it passed through, so only light in a single plane appeared on the overhead screen.*

3. What was the function of the optically active solution, the corn syrup? How did the corn syrup and the polarizing filter work together to produce the rainbow of colors on the overhead?

*The corn syrup separated the light into separate wavelengths, so each was bent to a slightly different degree. Since each wavelength was on a different plane, only one plane of light was allowed to pass through each polarized filter wedge, resulting in a circular rainbow of colors.*

4. Optically active solutions like corn syrup contain isomers that are mirror images of one another. These isomers twist light waves that pass by them, either clockwise or counter-clockwise. What effect do you think this produces?

*The twisting of the light waves is responsible for the rotation of the spectrum on the overhead screen.*

## Further Reading

Hambly, G. F. J. Chem. Educ. **1988**, *65*, 623.

Hill, J. W. J. Chem. Educ. **1973**, *50*, 574.

Kolb, D. J. J. Chem. Educ. **1987**, *64*, 805.

Noller, C. R. J. Chem. Educ. **1949**, *26*, 269–270.

Shakhashiri, B. Z. Chemical Demonstrations; The University of Wisconsin: Madison, WI, 1989; Vol. 3, pp 386–389.

## Flinn Scientific—Teaching Chemistry™ eLearning Video Series

A video of the *Kaleidoscopic Activity* activity, presented by Jeff Hepburn, is available in *Structures of Organic Compounds*, part of the Flinn Scientific—Teaching Chemistry eLearning Video Series.

## Materials for *Kaleidoscopic Activity* are available from Flinn Scientific, Inc.

Materials required to perform this activity are available in the *Kaleidoscopic Activity—Chemical Demonstration Kit* available from Flinn Scientific. Materials may also be purchased separately.

Catalog No.	Description
AP8781	Kaleidoscopic Activity—Chemical Demonstration Kit
AP8913	Polarizing Film, 6" × 6"
C0091	Corn Syrup, 16 oz

Consult your *Flinn Scientific Catalog/Reference Manual* for current prices.



# Polarized Filter Pattern

