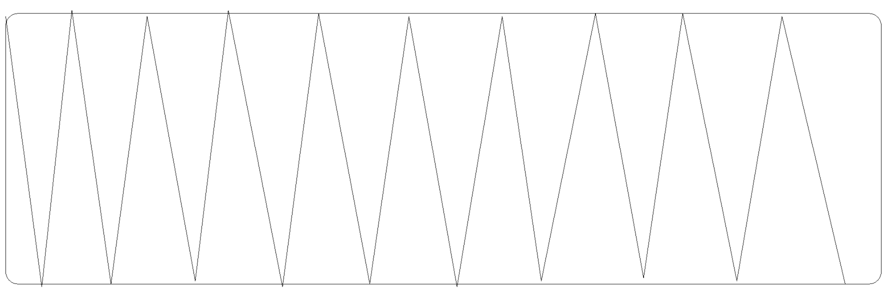
THE OVERHEAD PROJECTOR POLARIMETER

Materials Needed

Polarizing filter, approximately 7 cm x 60 cm, polarized in the 7 cm direction
One piece about 15 cm x 15 cm
Ruler
Scissors
1 sheet laminating plastic, adhesive on one side
Tape
Beaker, 400 or 600 mL
White Karo syrup (corn syrup)
Overhead projector

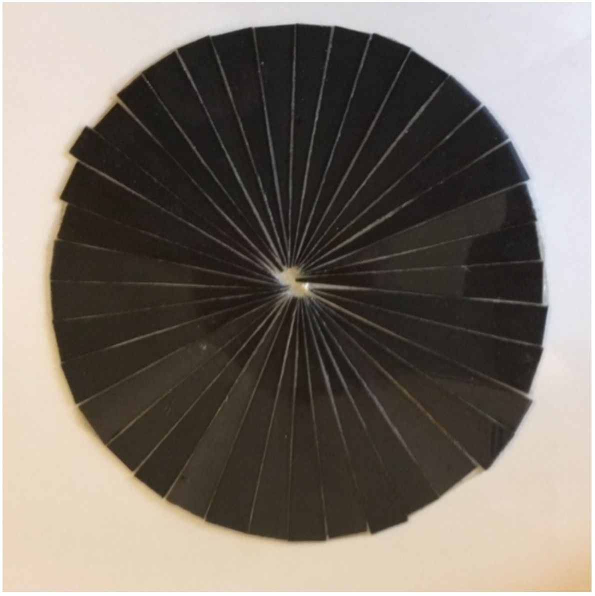
Directions

To create a circular polarizing filter, cut a series of triangular wedges about 14 mm on the wide side, from the 7 cm wide piece of polarizing filter.



On the sticky side of a piece of laminating plastic, arrange the wedges into a circle, similar to slices of a pie. Cut off the excess laminating plastic.

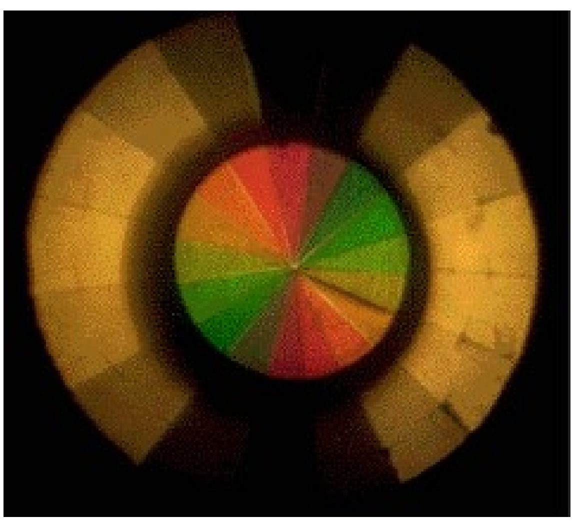
The finished "circular polarizing filer" is shown below.



Place the circular polarizing filter, laminated plastic side down on an overhead projector. Tape the rectangular piece of polarizing filter over the upper lens of the overhead projector.

Place the beaker on the circular polarizing filter. Add some Karo syrup to the beaker. Note the colors produced by the polarizing filter. Add additional Karo syrup, the colors will rotate around the circular polarizing filter.

The projected image is shown below.



Explanation

Ordinary light consists of waves vibrating in all planes perpendicular to the direction of propagation. A Polaroid filter, acts like a picket fence with narrow openings in it, that selectively transmits light waves vibrating in only one plane (or the direction of the openings). The resulting light is called **plane-polarized light**.

Some chemical compounds, which have asymmetric centers, are said to be **optically active** because they rotate plane polarized light.
An apparatus called a **polarimeter** is used to measure the optical activity of solutions of chemical compounds. It consists of a light source, a polarizing filter (which generates the plane-polarized light), and sample tube and an analysing filter (a second polarizing filter). If a solution containing an optically active substance is placed in the sample tube, it rotates the plane of the polarized light, and the degree of rotation can be measured.

If the solution rotates the light to the right (clockwise) it is called dextrorotatory and is designated with a + sign. If it rotates light to the left (counterclockwise) it is called levorotatory and it is designated with a – sign. The magnitude of the rotation is an intrinsic property of the molecule. The observed rotation depends on the concentration of the solution, the length of the sample tube, the temperature, and the wave length of the light source.

There is a standard, called the **specific rotation**. This is defined as the observed rotation when light at 5896 angstroms is used with a path length of 1 dm and a sample concentration of 1 g/ml.

Karo syrup is a solution of dextrose, or D-glucose, a right-handed sugar, with a concentration of approximately 3 M (moles per liter). That is, a solution of dextrose will cause light passing through it to rotate in the right hand direction. The literature value for the rotation of light for a water solution of dextrose is $[\alpha]_D$ +47.9° (a rotation of 47.9° to the right or clockwise rotation).

In this apparatus, the circular polarizing filter, made up of the wedges of polarizing filter, produces polarized light in many directions. The analyzing filter is a sheet of regular polarizing filter placed over the top lens of the overhead projector. The result is a projected series of wedges from almost colorless through a series of grays, to almost black (crossed polarizing filters which do not transmit light). When a glucose solution is placed in between the two polarized sheets, the light passing through the solution is rotated and slowed by the solution. This is observed by the appearance of colors on the projected wedges. As more solution is added to the beaker, the degree of rotation (increased concentration and increased path length) results in a greater degree of rotation of the light and the colors will move around the circle of wedges.

Acknowledgement

I first saw this demonstration performed by Robert Becker at a ChemEd conference.