Chromatography
Find the hidden rainbows in black marking pens!

Use water to separate the different colors used to create black marker ink.

Topics
Chemistry, Color, Pigments, Molecules

Materials
- ✓ Tall container/cup
- ✓ Straw, longer than container width
- ✓ Pencil
- ✓ Ruler
- ✓ Stopwatch or equal
- ✓ Paper towel/napkin
- ✓ Felt marker, black, water soluble
- ✓ Tape
- ✓ Water

Learning Standards
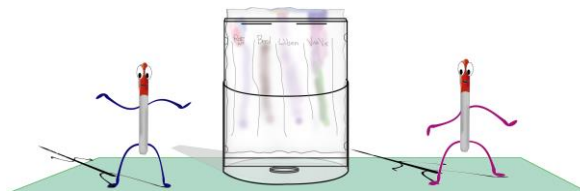NGSS: Structure and Properties of Matter
5-PS1-1
5-PS1-3
MS-PS1-1
MS-PS1-2

Assembly
1. Cut a rectangle strip, 2" wide by 7" long, from the paper towel/napkin.
2. Use a pencil and ruler to measure and draw a line that is 1" from the 2" wide edge of the rectangle strip.
3. Draw a 3/8" diameter dot with the black felt marker centered along the line.
4. Tape the opposite 2" end of the strip to the center of a straw. Lay the straw across the top of a container so the strip hangs down into the container.
5. If the strip is longer than the container, roll it around the straw so that it just touches the bottom of the container as it hangs down. Use more tape if needed.

To Do and Notice
1. Slowly add ½" of water to the container, making sure the marker dot is above the water line. Record the start time.
2. Observe the marker dot every 3 minutes and record/draw observations.
3. After 15-20 minutes, remove the straw and strip and lay on a paper towel.
4. Carefully measure and record the distance from the drawn pencil line to the bottom of each ink color (distance traveled upward along the strip).
5. **Older students:** Calculate R_f values by dividing the distances of each ink color by the distance the water traveled upward through the strip (see formula below). Note: Units for distance must be the same for ink and water (ex: 9 cm / 15 cm) so they cancel out of the calculation (R_f values are decimals without units).
6. **Further exploration:** Use plant pigments extracted from different types of leaves (citrus, other plants) and compare chromatography results.

$$R_f \text{ (retention factor)} = \text{Distance (ink color) / Distance (water)}$$

The Science Behind the Activity
The color "black", as a single color, does not actually exist. Pen manufacturers can create black using mixtures of colors using different combinations of pigments to create black ink. Chromatography is a process used to separate the substances contained in a compound. This helps scientists to study and identify substances. The bands of color are formed because different color molecules have different shapes, weights, sizes, and electric charges that can affect their solubility. The soluble color molecules dissolve in water and are moved upward due to capillary action. A color molecule that has greater solubility will be transported farther (higher R_f value) than molecules that have less solubility (lower R_f value).

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