Chroma-Tricks Experiment Kit

Teacher Notes

This class size kit contains 5 times the quantities of materials stated on the instruction booklet plus more filter paper circles, chromatography strips and cotton swabs. You may need more of these items depending on the size of your classes. Coffee filter paper is a good substitute for the paper strips.

Save the Eco-Foam packing material. It will be used in an experiment.

The Student Experiment Sheets have been taken from the instruction booklet and may be copied for student use. The experiments have been grouped and may appear in a slightly different order than in the booklet.

Sheet 1: Brief introduction and safety rules.
Sheet 2: The basic experiment and chromatography Experiment 1 and 2).
Sheet 3: More on chromatography (Experiment 3 and 10).
Sheet 4: Making and using the solutions (Experiment 4 and 5) and the chemistry behind the reactions. Sodium hydrosulfite (sodium dithionite) will reduce methyl orange.
Sheet 5: Flower power experiments (Experiments 6 and 7).
Finding household material that will act as the changers and pH of indicators (Experiment 8 and 9).
Sheet 7: Chromatography Art (Experiments 14 and 15).

Teacher Notes: Standards and Concepts

While the instruction booklet for this kit does not provide a complete discussion of the following terms, this kit will provide an opportunity to enrich and reinforce these concepts using a fun chemical system: color changing markers.

- scientific method - inquiry, observation, hypothesis, investigation, control of variables, inferring, recording, models
- solutions - dilution, use of pipet, pH
- chemical structures - dyes, chromophore
- mixtures - analysis of mixtures by chromatography
- chemical reactions - oxidation - reduction reaction, acid - base reaction
- science and history - development of chromatography
- science and art - chromatography art
- science and the environment - analyzing pigments in flowers
- science and technology - chromatography in forensics
- safety
Chroma-Tricks Experiment Kit

Chemistry of Color Changing Markers

Draw with the fascinating Color Changing "Magic Markers".

Then use chromatography to analyze the colors to learn the chemical secrets behind the color changes.

Make your own color changer.  Do Colorful Chromatographic Art!

And make amazing changes with the Flower Power experiment.

The original felt tip markers were called Magic Markers™, but the color changing markers appear really magical. With this kit you can use chromatography to "see into" the colors and discover the science behind the magic. And you can make beautiful color changes and learn some very interesting chemistry.

Caution! The Chroma-Tricks Experiment Kit is a safe experiment kit when used as directed. However, anything can be dangerous when used in the wrong way. Always use any chemical, including household chemicals, with care.

If you are allergic to sulfites, do not use this kit. Sodium sulfite may form sulfur dioxide, which is irritating to the eyes, nose, mouth, throat and lungs. Sulfur dioxide is a gas, or vapor, that will get into the air around the sodium sulfite. Always use good ventilation, that is, have good air circulation where you are working.

Wear safety glasses when using the chemicals in this kit.

Do not drink or taste the chemicals in this kit.

Keep the chemicals away from infants and young children.

If any chemical in this kit or any household chemical gets on the skin or in the eyes or mouth, the best first aid is to wash with lots of water.

If swallowed, drink a glass of water or milk and call a physician or the Poison Control Center.

Always ask permission to use any household materials.

Work on a newspaper or paper towel to make clean up easier.

Keep the caps on the bottles when not in use. Keep the right cap with the vial.

Use a clean dry scoop when taking a chemical out of the vial.

Read the directions carefully. Read the labels on the containers carefully. Never experiment with something you know nothing about.

Experiment with small amounts of materials. It will be less dangerous and easier to control than large amounts. And you will conserve your resources.

When finished, pour the liquids down the sink and run water for 1/2 minute.

Wash any cups and utensils that you used. And wash your hands and put away your materials.

The Chroma-Tricks Experiment Kit contains:

5 color changing markers,
citric acid (4 grams),
sodium carbonate (4 grams),
sodium sulfite (4 grams),
chromatography paper, cups, paper clip, pipet, cotton swabs, scoop, spoon, wooden stick, starch foam packing and this instruction booklet.

Other materials you may need: cup, small scoop, teaspoon, pipet, stirrer, cotton swab, paper towels, white paper to write on, paper coffee filters, tincture of iodine, ammonia, white vinegar, hydrogen peroxide, bleach, other felt-tip markers and flower petals.

Warning: The material in this kit is safe when used as directed. However, it contains chemicals that may be harmful if misused. Contains sodium sulfite. Not recommended for anyone allergic to sulfites. Recommended for age 9 and up with adult supervision.

Chemistry is fun, but always experiment carefully!

Now lets get ready to make some pretty awesome colors

Student Experiment Sheet. This may be copied for classroom use.
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Real Magic "Magic Markers" - The Question

Get a piece of notebook paper or other paper to write on (but not the paper that came with this kit). Make a mark or draw a small picture with one of the colored markers. Now take the white marker and rub over part of the mark that you made. Look at it and you will see it change colors. Maybe you have seen these types of markers before. The color on the barrel of the color changing markers is changed to the color on the cap by the white color changer marker.

How do you think it works? How does the color changer change the color of the mark? Scientists like to ask questions of how and why. This is also the first step in an investigation. Make a guess about how you think it happened. A hypothesis is an unproved statement or theory, or guess, to explain some event or happening. We will try to find out what caused the change. And you will be able to prove or disprove your theory.

A tip about the color changer tip: The color changer will pick up color from the ink marks. To minimize or decrease color pick-up, wipe the tip lightly with a damp paper towel after use.

Another way to use the markers is to first draw or write something with the white marker. Notice that its mark is colorless and invisible when it dries. Then rub over that invisible mark with one of the colored markers.

Experiment 1 We Need a Clue!

You will need the pipet (dropper), a cup with a little water and a piece of a paper towel. First practice using the pipet. To fill it, put the tip of the pipet in the water and squeeze the bulb. Watch as air bubbles come out. Keep the tip in the water and release the bulb and watch the water move up the pipet. Hold the pipet over the cup and practice squeezing out one drop at a time.

Make a mark with the black marker on the piece of paper towel. Now, using the pipet, put a few drops of water on the paper towel near the mark that you made. Watch it for a few minutes. The ink will run, spread out and blur. This would not be good if your homework gets caught in a rainstorm, but for us it is a clue. Notice that the ink blur is made of different colors.

We need clues to help us in our investigations. Sometimes "accidents" such as the ink running can lead to new discoveries. Always look carefully, or observe, the things around you and in your experiments. Things are often very different than they first appear. As we just saw, black is not always black.

Touch the white marker on different parts of the blurred mark on the paper towel. It may surprise you. Look carefully as the white marker touches some of the colors that had run.

Experiment 2 Chromatography

In this experiment you will do chromatography (pronounced cro-rna-ta-graf-e) which is a more sophisticated, or fancier, version of the ink running. Chromatography is the basis of many techniques for separating parts of a mixture that help chemists analyze, or examine, the materials in our world. You will need a cup, paper clip, wooden stick, a strip of chromatography paper (1/2" by 3 1/2" that is in this kit) and a little water.

Use this guide to help you prepare the chromatography paper. Make a mark with the black marker about 1/2 inch from one end of the strip and put another mark on the other end of the strip. That will be the control mark. It will help you to compare any changes after the experiment and also to identify the marker that you used. Make a fold in the strip, where the dotted line is. Put the strip in a dry cup and place the stick on top of the cup. Fold the paper over the stick so the end of the paper just touches the bottom of the cup. Use the paper clip to hold the paper on the stick.

Then take the paper and the stick out of the cup. Put 1 teaspoon of water in the cup. Then put the paper back in the cup so that the end of the paper is in the water, but the ink mark is not in the water. This is important so the ink will not run into the water, but the water will run up or be absorbed by the paper.

As the water moves up past the ink mark, different colors of ink will appear. Let it continue until the water is near the stick, then take the stick and paper out of the water and put the paper strip on a paper towel to dry. Save this for Experiment 3.

The black ink is really a mixture of several inks. Can you see the color that the black marker changed to in our first activity, on the paper strip in this experiment?

Repeat this experiment using the other color changing markers. If you need more chromatography paper, you can cut some from coffee filter paper or laboratory filter paper. Different paper may have different coatings and surfaces and may separate the inks differently. And some paper may react with and change the color of the markers.

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Chromatography

“Chromo” is a prefix that comes from a Greek word for color and “graph” is a suffix that comes from a Greek word for write or record. Chromatography is a physical process, or way, of separating parts of a mixture. It is based on the fact that at least one part sticks, or adsorbs, better to the paper (the stationary phase) than does another part. The ink that sticks better, does not move as far as the others. Also, it depends on how strongly the parts are attracted to the solvent (the moving phase). Water is the solvent in our experiments. If one ink is strongly attracted to water, it will move farther along and faster.

Chemists and other scientists can use chromatography to analyze or help find out what something is made of. It is a way to "see" the parts of mixtures and to compare them to try to identify each part. In our experiment, we found out that the ink in the markers is made of several different inks.

Experiment 3 The Reaction Rub
Take the paper strip from the black marker in Experiment 2. How many different colors can you identify? You may see yellow, light blue, dark blue and pink. Now rub the white color changer over part of each color on the paper. What happened? The color changer reacts with some of the inks and makes some colors disappear, changes some and not affect others.

The control mark allows us to look at the "before" and compare it to the change after the experiment. This is very important in experiments so we can know what changed.

We are now beginning to understand how the color changers work. There are several inks in each colored marker. Part of the ink is actually changing colors and there is also a "hidden" color that appears when one or more of the other colors disappear.

If you made chromatograms of all four of the colored markers, look at them together. Can you see any parts that are the same? Notice that the same color appears in the same position in the black and the green markers. They have some of the same ink(s) in them. An important use of chromatography is to analyze materials and to determine if they are the same or different.

More on Chromatography
In 1906, a Russian botanist named Mikhail Tswett discovered the process of chromatography that we used in Experiment 2. A botanist is a scientist that studies plants. He was surprised to find that a green plant such as spinach has a mixture of colors in it. He could separate only simple materials that give visible color changes.

Now more advanced techniques or methods, can separate and identify "invisible" drugs in blood. Even individual people can be identified by their DNA, the basis for the genetic code in cells. Police crime labs can analyze a paint chip and tell if it came from a certain car, and if the ink from a note used in a bank robbery came from the suspect’s pen. Chromatography can tell.

You can improve the separation of inks in your experiments. Try using a longer strip of paper and a taller cup or container for the water. That will give a longer distance for the substances to move and be separated. Chemists use ultra-violet light (UV or black light) to see some compounds that are not visible. If you have such a lamp then look at the inks from your experiments with it.

Experiment 10 Plant Chromatography
You can try chromatography on one of the colorful petals. Put a few petals in a cup with a dropper full of water. Mash it gently with the spoon for a minute. The water will extract, or take out, some of the colored material. Use the dropper and put this colored liquid, or extract, on a piece of chromatography paper as in Experiment 2, or on a piece of paper towel for the quick method as in Experiment 1.
Experiment 4 The Solution

Chemists use the word solution to mean something dissolved in something else. Solution also means an answer to a problem. We will use solutions to find the solution to the question of what chemicals made the colors change. Use a dictionary if you are not sure of the meaning of a word.

Take the 3 plastic cups and add one teaspoon of water to each. Then add one small scoop of sodium sulfite to one and swirl gently to dissolve the crystals. Label the cup so you will not get mixed up. The sodium sulfite dissolves in the water and becomes invisible. It looks like water, but is now a sodium sulfite solution. Add one small scoop of sodium carbonate to the second cup and one small scoop of citric acid to the other cup. Swirl each gently to dissolve the crystals.

Make several marks with one of the colored markers on a piece of paper. Take a cotton swab and just dip it in the sodium sulfite solution and touch the wet end on the mark. Do not get it too wet or it will run. What happened to the mark? It should change colors just like when you used the white color changer. It appears to contain the same or similar chemical. Use new swabs and put a dab of the sodium carbonate and citric acid solutions on the other marks. What happens? Make marks with the other colored markers and repeat this experiment with those colors.

Experiment 5 The Reverse Rub

Take the marks from Experiment 4 and try touching the spots, using the cotton swabs, with each of the other solutions. That is, touch the sodium carbonate spots with the citric acid and sodium sulfite solutions. When using the cotton swabs, apply as little of the solution as possible. Squeeze out by pressing the swab against the upper part of the cup.

Try to figure out if any of the solutions react with any of the others. Make more marks. Try to use a system to try all the possible combinations.

You should observe that the citric acid can reverse the effects of the sodium carbonate. But most of the effects of the sodium sulfite can not be reversed. This is evidence for us to use to understand the reactions.

The Chemistry

There are two different types of chemical reactions going on in the changeable markers. One is an acid-base reaction and the other is an oxidation-reduction reaction.

Sodium carbonate has the formula Na₂CO₃ and reacts as a base. A base is a substance that reacts with hydrogen ions (H⁺). If a base can remove certain hydrogens from an ink or dye, its structure will change and its color changes.

Citric acid has the formula H₃C₆H₅O₇ and is an acid. An acid gives hydrogen ions when it reacts. Acids can react with and neutralize bases. Neutralize means to counteract or to destroy the activity of something. Acid-base reactions involve adding and removing hydrogen ions.

Sodium sulfite has the formula Na₂SO₃ and is used in industry to bleach paper and fabric. It is a reducing agent. In chemistry, a reducing agent gives or donates electrons. Oxidation-reduction reactions involve a transfer of electrons. Something loses electrons (oxidation) while something else gains electrons (reduction).

pH is a term for measuring acidity. Water is neutral and has a pH of 7. Bases have a pH greater than 7 and acids have a pH less than 7. A solution of sodium carbonate has a pH between 11 and 12. Sodium sulfite has a pH about 9, which also makes it a weak base and it can change some ink colors by acting as a base. Citric acid has a pH of about 2. If citric acid changes back one of the colors, that change is due to an acid-base reaction. If citric acid can not reverse the change, then it was due to an oxidation-reduction reaction.

Dyes

Dyes are colored substances that can attach to fibers in paper or cloth. All colored materials absorb certain wavelengths of visible light and reflect other colors. We see the reflected color. The part of the dye molecule that is responsible for absorbing light is called a chromophore (from the Greek chroma = color and phoros = bearer). The azo group, -N=N-, is one type of chromophore that is in some of the dyes that disappear in the color changers. Azo refers to nitrogen (N). Other parts of the dye molecule are responsible for the intensity of color and how it bonds to fabric. The dyes that disappear or change with the white marker or run with water, would not make good fabric dyes. But they are great for our experiments.

Another class of dyes used in these inks are called cyanine (pronounced cy-a-nine) dyes. Most of the dyes in the marker inks are not very common because they are unstable. Methyl orange is a common azo dye used in the laboratory. The following shows how the structure of methyl orange will change with acid-base and oxidation-reduction reactions. A stronger reducing agent than sodium sulfite is needed to make the colorless reduced form.
Experiment 6  Flower Power Rub

This is an amazing experiment that you can do with flower petals, a sheet of white paper and the white color changing marker. You may be able to get some unwanted flowers for free at a flower shop. Get several different kinds.

Take a sheet of white paper and rub a petal on the paper. Write the name of the flower next to it so that you can identify it later. Rub the white color changing marker over part of the rubbing from the petal. Try other types of flower petals. You should see some surprising and beautiful color changes.

Experiment 7  Flower Power Solutions

Now you can try the 3 solutions that you used in Experiments 4 and 5 on the flower petal rubbings. Make more petal rubbing on a sheet of white paper. Write the name of the flower next to it so that you can identify it later. Make up more of the 3 solutions if needed as shown in Experiment 4. Put a dab of each solution on each flower rubbing.

Flower petals and leaves often have a waxy coating that protects the plant and keeps the solutions such as the ones we are using from contacting the pigments in plants cells. Pigments are the colored matter in plants and paints. Petal rubbings are a good way to extract those dyes and make them available to react and to keep.

After you find a few petals that give interesting color changes, try rubbing one petal over another petal rubbing. Try putting a dab of the 3 solutions on that combination.

Some plant petals will not change with any of the solutions. Some will change with the citric acid and sodium carbonate, but not with the sodium sulfite. Try white flower petals, you may be surprised again. Try a radish skin and some other fruits and vegetables. Notice how sunlight can bleach or fade some flower colors. Those colors will also react easiest with sodium sulfite.

Experiment 8  Household Changers

Make more marks with the colored changers and try to find some other substances that will act like the sulfite, carbonate and citric acid. Try ammonia, vinegar and a clear carbonated beverage such as "7-Up" or "Sprite". You can use toothpicks to apply a dab of the solution to the mark. Ammonia will act like sodium carbonate, they are both bases. Vinegar and carbonated beverages will act like citric acid, they are acids.

Try bleach. Ask permission and help to use bleach and be very careful. Pour a little bleach into a cup of water to dilute it. That makes it easier and safer to use. Bleach is a very strong oxidizing agent and will decolorize or “bleach” many inks completely. Look for sulfite in some store products. Look at the labels in the cleaning products section in stores. Write down your results to keep a record of your experiments.

Experiment 9  Indicators

Dyes that can change colors are very useful as pH indicators in chemistry. Indicate means to show or tell something. pH is related to the amount, or concentration, of hydrogen ions in solution. Some dyes will change color at a certain pH.

Make a large mark with each of the markers on a sheet of white paper. Then put a dab of each of the following solutions on each mark and label the spot. Then determine the lowest pH value that each marker changes at. The pH values are approximate for a dilute solution.

<table>
<thead>
<tr>
<th>Solution</th>
<th>pH</th>
</tr>
</thead>
<tbody>
<tr>
<td>citric acid</td>
<td>2</td>
</tr>
<tr>
<td>vinegar (acetic acid)</td>
<td>3</td>
</tr>
<tr>
<td>baking soda</td>
<td>8</td>
</tr>
<tr>
<td>ammonia</td>
<td>11</td>
</tr>
<tr>
<td>sodium carbonate</td>
<td>12</td>
</tr>
<tr>
<td>sodium hydroxide</td>
<td>13</td>
</tr>
</tbody>
</table>

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Experiment 11 The Iodine Marker

You will need tincture of iodine for this experiment. It is sold in drug stores and is used to treat cuts. Always ask permission to use any household materials. Be careful, iodine will stain. Tincture means an alcohol solution of some substance.

Touch the applicator of the iodine bottle on the bottom of a clean cup. This will place a drop there. Place 2 or 3 drops of iodine in the cup this way. Add a teaspoon of water. This will dilute the iodine and make it easier to use and less likely to stain.

Now dip a cotton swab in the iodine solution and make a mark or drawing on a piece of white paper. Notice that the mark turns dark; it may even appear blue. Let the mark dry, then rub over it with the white color changing pen. What happens? The iodine color should disappear.

Try your solution of sodium sulfite on it. What happens?

The iodine in the tincture of iodine is a mixture of several forms of iodine. We will simplify it as molecular iodine with the formula I₂. Tincture of iodine has a brown color. When put on paper it may turn blue. Some paper is coated with starch to make it smoother. Starch reacts with iodine and turns blue. Sodium sulfite in the white pen and in your solution, reacts with iodine and changes iodine to iodide which is colorless. This is an oxidation-reduction reaction.

The Chemistry of the Iodine Marker

Iodine in the free element state is a shiney purple crystal. Tincture of iodine is a brown liquid. Starch and iodine form a dark blue color. But iodide, which is a negatively charged iodine atom or iodine ion, is colorless.

This all may seem strange, but as the atomic or molecular structure changes, the color, or the wavelength, of light that can be absorbed also changes. This is useful to us because we can "see" what chemical changes are taking place. If something is colorless, it absorbs no visible light and reflects all light. The following are the chemical equations for the reaction of the iodine mark with the white color changer:

I₂ (blue with starch) + 2e⁻ → 2I⁻ (colorless) reduction (gain of electrons)
Na₂SO₃ + H₂O → Na₂SO₄ + 2H⁺ + 2 e⁻ oxidation (loss of electrons)

Experiment 12 The Starch Iodine Test

Make more of the dilute iodine solution that you used in Experiment 11 (2 or 3 drops of tincture of iodine in a teaspoon of water). Take a piece of the foam packing material that came in this kit, tear off a small piece and put it in the iodine solution. Watch as it dissolves and begins to turn blue. This reaction is a way to test for iodine or dilute starch. If an unknown substance turns starch blue, then we can conclude that it is iodine. If a substance turns iodine blue, then that substance contains starch.

Save the blue solution for the next experiment. The foam packing is made of cornstarch and reacts with the iodine solution. It will dissolve and will not add to the filling of landfills as will polystyrene foam packing. Starch is also a renewable resource (corn) and is biodegradable. That means it can be decomposed by bacteria in a natural way.

Experiment 13 Disappearing-Reappearing Iodine

You will need a small amount of hydrogen peroxide for this experiment. It is sold in drug stores and is commonly used to treat small cuts.

Take the blue solution from Experiment 12 and add a very small amount (1 or 2 crystals) of sodium sulfite. Swirl it and watch as the color disappears. Iodine is changed to iodide.

Now add a few crystals of citric acid and then a few drops of hydrogen peroxide and swirl to mix. The blue should reappear. Try adding more sulfite. What happens? Then add more hydrogen peroxide. What happens? This is a reversible oxidation-reduction reaction.

I₂ (blue with starch) + 2e⁻ → 2I⁻ (colorless) sulfite (reduction)
H₂O₂ → H₂O + O₂ + 2 e⁻ hydrogen peroxide (oxidation)

Reversible means to be able to go in the opposite direction. Reversible reactions are very important in nature. For example, every time we move a muscle chemicals, such as enzymes, react. To move the muscle again, other chemicals must undo or put back the first reaction. Recycle means to put back and use again. We can recycle everything, if we have the right reactions.

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Experiment 14 Chromatography Art

Many of the color changes and color separations in these experiments have been very beautiful. Now we will try to create a work of art using chromatography. Chemistry and art always go together. The early artists often had to make their own paints. The names of paint such as cobalt blue and cadmium yellow tell us something of the importance of chemistry in art. Making paint and glaze for ceramics involve knowledge of chemical composition and properties. Understanding the different inks in the markers and how they absorb and move on the paper will help in your artistic design.

Take the round piece of paper that came with the kit. It is the kind of filter paper used in a laboratory, but now it will be your canvas. Look at the colored markers and visualize in your mind the different colors in the inks and how they can spread out. Look at the results from your other experiments to help you.

Now take the colored markers and make some small patterns or draw a picture on the round paper. Place the paper on top of a plastic cup. Put a few drops of water on the paper with the dropper. Watch the ink run. Add a few more drops of water if necessary to develop what you think is an interesting image. Set it aside to dry. Use the white marker on it if you like.

Make more paper for more art works. Try coffee filter paper and different brands of paper towels. And this takes us back to where we started in Experiment 1. But now we know a little more about how some of these beautiful processes work.

Experiment 15 More Chromatography Art

Try this variation of Experiment 14 to make more "chromatographic paintings". This change in the technique will allow water to flow out from the center, or radiate.

Take a piece of paper towel and cut it into a triangle about 3 inches long. This will be a wick. Take another piece of the round filter paper, or make some from coffee filter paper or other absorbent paper. Poke a hole in the center of this paper with a toothpick or end of a pencil. Draw on the round paper as before. Put the small end of the wick in the hole in the round paper and pull so that the tip comes through. Put 2 teaspoons of water in a cup and place the wide end of the wick in the water and let the paper rest on top of the cup. The water will move up the wick and onto the paper. The water will spread out in a circle and separate the inks as before.

Try other felt tip markers. What do you think will happen if you use a permanent type marker? Why?