Non-Newtonian Fluids

Introduction:
A non-Newtonian fluid is a fluid that does not follow Newton's Law of Viscosity i.e., constant viscosity independent of stress. In non-Newtonian fluids, viscosity can change when under force to either more liquid or more solid. Many fluids exhibit this property: ketchup, honey, dish soap, and toothpaste are a few examples. This experiment is geared towards making a corn starch mixture to show the various properties of non-Newtonian fluids.

Ingredients:

- Corn starch
- Water
- Container

Protocol:

1. Add ¼ cup of dry cornstarch to the bowl.
2. Add about 1/8 cup (2 tablespoons) of water to the corn starch and stir slowly.
3. Add water slowly to the mixture, with stirring, until all of the powder is wet.
4. Continue to add water until the cornstarch acts like a liquid when you stir it slowly.
   NOTE: When you tap on the liquid with your finger, it shouldn't splash, but and will become hard. If your mixture is too liquid, add more cornstarch. Your goal is to create a mixture that feels like a stiff liquid when you stir it *slowly*, but feels like a solid when you tap on it with your finger or a spoon.

Results and Discussion:
Why does the cornstarch mixture behave like this? Think of a busy sidewalk. The easiest way to get through a crowd of people is to move slowly and find a path between people. If you just took a running start and headed straight for the crowd of people, you would quickly slam into someone and you wouldn't get very far. This is similar to what happens in the cornstarch mixture. The solid cornstarch acts like a crowd of people. Pressing your finger slowly into the mixture allows the cornstarch to move out of the way, but tapping the mixture quickly doesn't allow the solid cornstarch particles to slide past each other and out of the way of your finger.

We use the term "viscosity" to describe the resistance of a liquid to flow. Water, which has a low viscosity, flows easily. Honey, at room temperature, has a higher viscosity and flows more slowly than water. But if you warm honey up, its viscosity drops, and it flows more easily. Most fluids behave like water and honey, in that their viscosity depends only on temperature. We call such fluids "Newtonian," since their behavior was first described by Isaac Newton (when he wasn't discovering the laws of gravity or developing the calculus). The cornstarch mixture you made is called "non-Newtonian" since its viscosity also depends on the force applied to the liquid or how fast an object is moving through the liquid.

References:
[1] http://www.scifun.org/HomeExpts/lumpyliquids.htm

Slime

Introduction:

Slime involves chemistry! Chemistry is all about states of matter including liquids, solids, and gases. It is all about the way different materials are put together, and how they are made up of atoms and molecules. Slime is a non-Newtonian fluid. A non-Newtonian fluid is neither a liquid nor a solid. It can be picked up like a solid, but it also will ooze like a liquid. Slime does not have its own shape. You will notice your slime change its shape to fill whatever container it is placed in.

Ingredients:

- White glue
- Borax
- Spoons
- Cups
- Popsicle stick
- Water
- Food coloring

Protocol:

1. Place 1 tablespoon of water in a small plastic cup. Add ¼ teaspoon of borax. Mix until as much borax dissolves as possible. This is your If you would like your slime to be a certain color, add one or two drops of food coloring to your borax solution.
2. Place 1 tablespoon of water in another cup and add 1 tablespoon of Elmer's glue. Stir with a popsicle stick until the glue and water are thoroughly mixed. This is your glue solution.
3. Slowly pour all of the borax solution into the glue solution, and stir with a clean popsicle stick. You should notice a sudden change in the solutions.

   NOTE: Your slime is done when you can pick up your popsicle stick and most of the slime comes out on the stick.
4. When you have some nice thick slime, pull it off the popsicle stick and move it back and forth between your hands. The more you play, the less sticky it gets.

Results and Discussion:

What makes slime so thick and stretchy? The glue has long flexible molecules in it called polymers. These polymer molecules slide past each other as a liquid. Borax in water forms an ion called the borate ion. When the borax solution is added to the glue solution, the borate ions help link the long polymer molecules to each other so they cannot move and flow as easily. When enough polymer molecules get hooked together in the right way, the glue solution changes from being very liquidy to a rubbery kind of stuff that we call slime!

References:

[1] https://www.acs.org/content/acs/en/education/whatischemistry/adventures-in-chemistry/experiments/slime.html
[2] https://littlebinsforlittlehands.com/basic-slime-science-homemade-slime-for-kids/

Penny and Water

Introduction:
Have you ever noticed on a rainy day how water forms droplets on a window? Why does it do that instead of spreading out evenly over the whole surface? It all has to do with something called surface tension. Surface tension describes the tendency of liquids to shrink into the minimum surface area possible. This experiment shows differences in surface tensions of various fluidic substances.

Ingredients:

- Penny
- Medicine dropper or eyedropper
- Glass, cup or small bowl
- Tap water
- Dish soap
- Dish towel or paper towel
- Flat, level surface that can get wet, such as a kitchen counter
- Paper and pencil or pen (optional)

Protocol:

- Place the penny on a flat, level surface
- Fill a glass cup or bowl with tap water
- Fill the medicine dropper with water
- Now carefully add one drop of water at a time to the top of the penny.
  NOTE: Hold the medicine dropper just above the top of the penny (not touching it) so each new drop has to fall a short distance before it merges with the drop on the penny. You can write down the number of drops you add if you like.
- Keep adding drops (refill your medicine dropper as necessary) one at a time.
- Once the drop spills over the penny's edge, use a towel to completely dry off the penny and surrounding surface.

Results and Discussion:
How many drops of water do you think will fit on top of the penny? You have probably noticed that if you look at a surface outside on a rainy day or spill some water inside, the liquid tends to form droplets that stick up from a surface instead of spreading out. This occurs because water is made up of many tiny molecules that are all attracted to one another. Molecules in the middle of a drop of water are pulled evenly in all directions by all the nearby molecules. Those near the droplet's surface, however, are pulled mostly inward by the water molecules below them. This creates "surface tension." The surface of the water droplet is held together by the attraction between molecules. Now, think about washing dirty dishes or clothing. There will be lots of tiny little holes and cracks that water needs to get into to wash away dirt and grime, such as the spaces between the fibers of a shirt or between a plate and bits of dried food. In order for water to flow more easily into these small spaces, you need to *decrease* its surface tension. You can do this by adding soap, which is a surfactant (a material that decreases the surface tension of a liquid). In this activity you will see how soap decreases the surface tension of water by putting water droplets on top of a penny.

References:
[1] https://www.scientificamerican.com/article/measure-surface-tension-with-a-penny/

MAKE A PAPERCLIP FLOAT!

YOU WILL NEED:

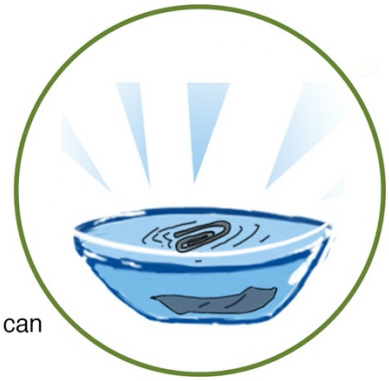
- Clean dry paper clips
- Tissue paper
- A bowl of water
- Pencil with eraser

WHAT TO DO

1. Fill the bowl with water
2. Try to make the paper clip float…not much luck, huh?
3. Tear a piece of tissue paper about half the size of a dollar bill
4. GENTLY drop the tissue flat onto the surface of the water
5. GENTLY place a dry paper clip flat onto the tissue (try not to touch the water or the tissue)
6. Use the eraser end of the pencil to carefully poke the tissue (not the paper clip) until the tissue sinks. With some luck, the tissue will sink and leave the paper clip floating!

HOW DOES IT WORK?

How is this possible? With a little thing we scientists call SURFACE TENSION. Basically it means that there is a sort of skin on the surface of water where the water molecules hold on tight together. If the conditions are right, they can hold tight enough to support your paper clip. The paperclip is not truly floating, it is being held up by the surface tension. Many insects, such as water striders, use this “skin” to walk across the surface of a stream.



MAKE IT AN EXPERIMENT:

The project above is a DEMONSTRATION. To make it a true experiment, you can try to answer these questions:

1. How many paperclips can the surface tension hold?
2. Does the shape of the paperclip affect its floating ability?
3. What liquids have the strongest surface tension?
4. Can the surface tension of water be made stronger? (try sprinkling baby powder on the surface)

Density

Introduction:
Great science comes in all shapes and sizes, but we understand and seek to further understand science by asking '*why*?' For example, *why* do objects that are the same size sometimes have different weights? The answer has to do with their *density*. An object's density is determined by comparing its mass to its volume. There are many science experiments that help us see how various items have different densities. If you compare a rock and a cork that are the same size (meaning they have equal volume), which is heavier? The correct answer is the rock, because it has more mass. This is due to the atomic structure of the elements, molecules, and compounds that make it up. Liquids have density too! You can perform several science experiments with different types of liquids to determine which is more dense. From 5 year olds to high school students, this cool science activity to test varying densities is engaging for all ages.

Ingredients:
Glass jars or clear plastic cups

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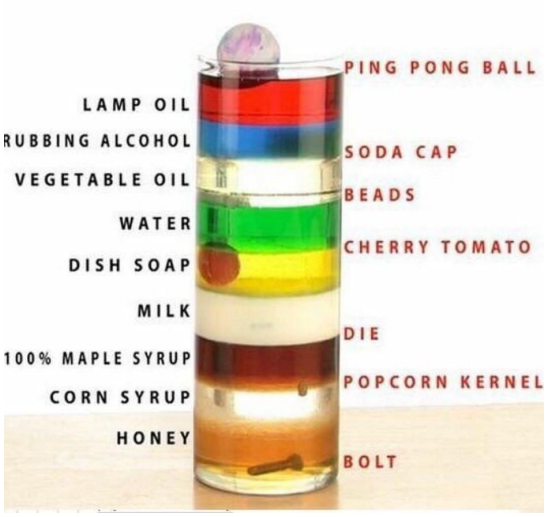
- Water
- Food coloring
- Various fluids (ie. corn syrup, vegetable oil, dish soap, etc.)



Protocol:

1. Fill each cup half-way with water
   NOTE: You will need a cup for each fluid you want to test
   For more fun, color the water to make it easier to tell the two layers apart!
2. Make a prediction about which fluid will be more dense, the water or the tested fluid
3. Add the first liquid to the cup
4. Make observations on which liquid is on top and which is on bottom

Results and Discussion:
The liquid you thought was densest should be at the bottom of the jar and the least dense will float at the very top. For more fun you can add multiple fluids to the same cup and see how the densities of the three liquids compare to each other. If you want to find out the approximate density of each, you can calculate it using this formula: Density = Mass/Volume. On Earth we measure mass (how much of a substance there is) by calculating weight (how heavy it is). Weigh each liquid in grams (make sure you subtract the weight of the cup) and then divide that number by the volume (number of milliliters) of the liquid. The answer is density in grams per milliliter.

References:
[1] https://www.homesciencetools.com/article/liquid-density-project/

BUILD A SOAP-POWERED MODEL BOAT!

YOU WILL NEED:

- A foam tray (like the kind meat comes in) or a piece of non-currogated cardboard
- A tray, bowl, or cookie sheet full of water
- Liquid dish soap
- A toothpick

WHAT TO DO

1. Cut the foam tray or cardboard into a boat shape as shown here. A good size seems to be about 2 inches long.

2. Dip the toothpick into the liquid soap and use the toothpick to put soap onto the sides of the notch at the back of the boat.

3. That's it! Now carefully place the boat onto the surface of the water and watch it scoot across the water for several seconds - you've made a soap-powered boat! To demonstrate the boat again, you will need to rinse out the tray to remove any soap from the previous demonstration.

HOW DOES IT WORK?

Soap is a rufactant - that means that it breaks down the surface tension of water. As the surface tension is broken up, it creates enough of a force to push the lightweight boat across the surface.

MAKE IT AN EXPERIMENT:

The above is a DEMONSTRATION. To make it a true experiment, you can try to answer these questions:

1. Does liquid soap last longer than a solid piece of soap?

2. Does warm water work better than cold water?

3. What materials make the best floating boat?

MAKING AN INDICATOR FROM RED CABBAGE

The compounds that give red cabbage its colour can be extracted and used as a pH indicator solution. Here we look at the method and the colours!

MAKING THE INDICATOR

1. ROUGHLY CHOP THE CABBAGE

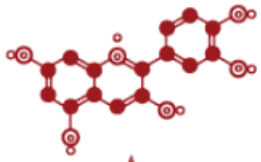
2. BOIL FOR A FEW MINUTES

3. STRAIN AND LET COOL

4. USE AS AN INDICATOR!

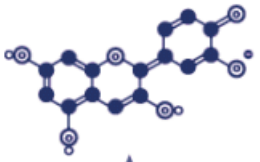
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14

ACIDIC — pH — ALKALINE

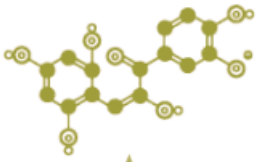


RED (pH <3)

VIOLET (pH 4–7)



BLUE (pH 7–8)



YELLOW GREEN (AT pH >8)

Hydrogens on carbon atoms implied; each carbon has 4 bonds.

The red cabbage extract can be used to determine whether substances are acidic or alkaline. The structures of the anthocyanin pigments which give the red cabbage its colour are subtly changed at varying pH. These different structures give a range of colours.

MAKE YOUR OWN VOLCANO!

YOU WILL NEED:

- A volcano - Talk to an art teacher about making a volcano out of papier mache or plaster. You can also use clay or if you're in a hurry to make your volcano, use a mound of dirt outside.
- A container that 35mm film comes in or similar size container.
- Red and yellow food coloring (optional).
- Vinegar
- Baking soda
- Liquid dish washing soap

WHAT TO DO

1. Go outside or prepare for some clean-up inside.
2. Put the film container into the volcano at the top.
3. Add two spoonfuls of baking soda.
4. Add about a spoonful of dish soap.
5. Add about 5 drops each of the red and yellow food coloring.
6. Now for the eruption!: Add about an ounce of the vinegar into the container and watch your volcano come alive!

HOW DOES IT WORK?

A VOLCANO is produced over thousands of years as heat and pressure build up. That aspect of a volcano is very difficult to recreate in a home experiment. However this volcano will give you an idea of what it might look like when a volcano erupts flowing lava. This is a classic experiment in which a CHEMICAL reaction can create the appearance of a PHYSICAL volcano eruption. You should look at pictures of volcanoes to be familiar with the different types. (A SHIELD volcano, for example is the most common kind of volcano, and yet few people know about them.) The reaction will bubble up and flow down the side like a real volcano (only much faster!) Look for videos of volcanoes erupting and be sure that you understand how heat and pressure work to really make volcanoes erupt.

MAKE IT AN EXPERIMENT:

The above is a DEMONSTRATION. To make it a true experiment, you can try to answer these questions:

1. Does vinegar temperature affect how fast the volcano erupts?
2. Does the shape of the volcano affect the direction the eruption travels?
3. What can be added to the "lava" to slow it down and make it more like real lava?
4. What combination of vinegar and baking soda creates the biggest eruption?

BUILD A FIZZ INFLATOR!

YOU WILL NEED:

- One small empty plastic soda or water bottle
- 1/2 cup of vinegar
- Small balloon
- Baking soda
- Funnel or piece of paper

WHAT TO DO

1. Carefully pour the vinegar into the bottle

2. This is the tricky part: Loosen up the balloon by stretching it a few times and then use the funnel to fill it a bit more than halfway with baking soda. If you don't have a funnel you can make one using the paper and some tape.

3. Now carefully put the neck of the balloon all the way over the neck of the bottle without letting any baking soda into the bottle.

4. Ready? Lift the balloon up so that the baking soda falls from the balloon into the bottle and mixes with the vinegar. Watch the fizz inflator at work!

HOW DOES IT WORK?

The baking soda and the vinegar create an ACID-BASE reaction and the two chemicals work together to create a gas (carbon dioxide.) Gasses need a lot of room to spread out and the carbon dioxide starts to fill the bottle, and then moves into the balloon to inflate it.

MAKE IT AN EXPERIMENT:

The project above is a DEMONSTRATION. To make it a true experiment, you can try to answer these questions:

1. Does water temperature affect how fast the balloon fills up?

2. Does the size of the bottle affect how much the balloon fills?

3. Can the amount the balloon fills up be controlled by the amount of baking soda?