# Gak and the Non-Newtonian Fluid

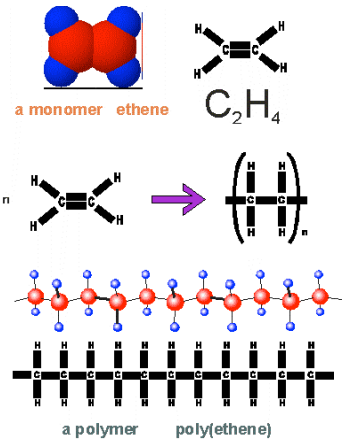
## The Big Idea

1) A polymer consists of long chained molecules that are bound together.

2) Non-Newtonian fluids are those that have viscosities that change with conditions of stress or time.

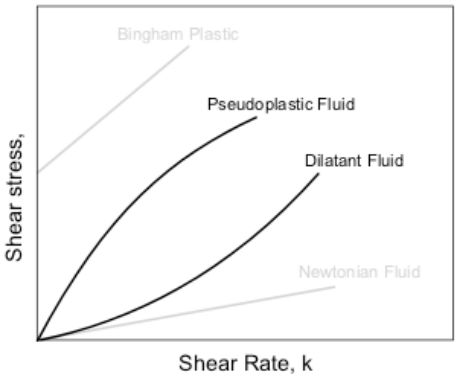
## Background

Gak – Glue consists of long chained molecules that are very loosely tied together, which explains why it has a higher viscosity than water. When mixed with Borax, the molecules are "tangled" and a chemical reaction takes place. The tangled chains are polymers which is what plastics are and other man made substances such as nylon.




http://www.petervaldivia.com/technology/plastics/image/polymer.gif&imgrefurl=http://www.petervaldivia.com/technology/plastics/index

A **Non-Newtonian** fluid is one that is not characterized by one viscosity. Such fluids have viscosities that change as a function of stress, time or both. A mixture of cornstarch and water flows when little stress is applied, yet acts like a solid when a lot of stress is applied – for example, hitting the surface with your hand or even jumping quickly on it. Uses of such fluids may be in body armor. There are other non-Newtonian fluids that have the opposite reaction to stress. Fluids such as ketchup become less viscous when stress is applied (hence hitting the bottle of ketchup allows the ketchup to flow out).




http://upload.wikimedia.org/wikipedia/commons/f/f0/Non-Newtonian_fluid.PNG

Cornstarch and water mixture

Cornstarch and water mixture on a speaker

# Materials

### Demonstration – polymers

Various plastic containers.

### Demonstration – Viscosity

Plastic board
Various liquids of different viscosity to drip on slanted board and watch run them run off
Ketchup in a glass bottle

### Gak (per group)

Dixie cup for mixing
Wooden stirrer
Small plastic ziplock bag for storing
Borax/water mixture
Glue/water mixture
Food Coloring if desired

### Demonstration – Pool of Cornstarch/water

cornstarch:water is 4:1
Aluminum pan of cornstarch/water.

# Procedure

**To prepare <u>before</u> the session:**

1. **About 30 minutes before the event**, start making the Aluminum pan of Cornstarch/water. It takes a while and a lot of cornstarch, water and stirring to get a large enough pool that gives the WOW factor. This can get messy, please be aware of your surroundings in the classroom. Clean up, the whole tray can be thrown away in a large trash bin.

2. Prepare the Borax/water and glue/water solutions in bulk a head of time and arrange materials to be handed out smoothly.

**<u>During session</u>**

1. Ask participants to describe chemistry. Accept and acknowledge all relevant answers. Point out that by learning the chemistry that happens in nature, scientists have been able to create many new helpful products.

2. Introduce the first concept, which is that a polymers and long chained molecules that are bound together. Common polymers are plastics. Show the audience plastic containers and products. You can talk about the Fall FUSE Kelp Beads activity.

3. Start with one demo to illustrate polymerization.

Each Gak has a different recipe… In cup 1 mix glue, red food color, and weak borax solution. In cup 2 mix glue, blue foor color, and strong borax solution. Ask for volunteers to describe/compare/contrast what is in the cups.

Tell the families that they will now create their own polymer. They will start with a substance made of long chained molecules (glue) then through a chemical reaction bind them together by adding a borax solution.

a. Hand out necessary materials: cup of borax solution, glue solution already in zip lock bag, food color. Families can add color at this point if desired.

b. Walk around and add the borax solution to their cups and have them mix thoroughly. After they feel the mixture thicken (polymerization), have them remove the mixture and continue to knead the mixture with their fingers. ***Have them describe the changes they observed. Why can this new material stretch when glue and borax do not?***

4. Clean up and introduce a new substance – a fluid. Ask the families how fluids can be characterized or described. Accept and work with all answers. Eventually someone will mention how thick a fluid is and relate this to the term ***viscosity***. Demonstrate viscosity of fluids by having a fluid race down a cutting board. Place large drops of various fluids in a row along one side of a cutting board then raise that side of the board, so that the various fluids flow down the board. ***Viscosity is a liquid's resistance to flow***.

5. Tell the families that most liquids have a viscosity. But some liquids have different viscosities depending upon their environment. These fluids are called Non Newtonian fluids, for Newton had great explanations for how normal fluids flow. But the Non Newtonian fluids do not follow his models and calculations. For instance, some liquids decrease their viscosity when stress is applied. Show shaking ketchup out of a glass bottle as an example of such a fluid. The same concept is used in the ink of Space Pens – which can write upside down! This is because the ink is very viscous until pressure is applied, then it starts to flow.

Some fluids **increase** viscosity under stress or strain. Tell the families that they will now explore such a fluid. Invite families to come explore the aluminum pan of cornstarch and water.

| Type of behaviour | Description | Example |
|---|---|---|
| Thixotropic | Viscosity decreases with stress over time | Honey – keep stirring, and solid honey becomes liquid |
| Rheopectic | Viscosity increases with stress over time | Cream – the longer you whip it the thicker it gets |
| Shear thinning | Viscosity decreases with increased stress | Tomato sauce-Ketchup |
| Dilatant or shear thickening | Viscosity increases with increased stress | Oobleck |

Why does this even matter?

If a house is built on certain types of clays and an earthquake puts stress on this material through the sudden movement, the apparently solid clay can turn into a runny liquid.

Body armour that behaves like a liquid so that you can move easily but turns into a solid on impact from stress could be useful for police or the military.

Cleaning is an issue here, make sure there is a bucket of water for rinsing and paper towels.

# Resources

## Gak

http://www.californiasciencecenter.org/FunLab/DoItYourself/Gak/Gak.html

http://crafts.kaboose.com/homemade-kids-gooey-gak.html

chemistry.lsu.edu/outreach/webpub/Demo-2-Silly-Putty.doc

## Non Newtonian Fluid

http://en.wikipedia.org/wiki/Non-Newtonian_fluid

http://antoine.frostburg.edu/chem/senese/101/liquids/faq/non-newtonian.shtml

http://www.wisegeek.com/what-is-a-non-newtonian-fluid.htm

http://itotd.com/articles/624/non-newtonian-fluids/

**Fun with the stuff:**

- http://www.instructables.com/id/How-To:-Make-Non-Newtonian-Fluid-&-Experiment-wit/
- www.youtube.com/watch?v=f2XQ97XHjVw Pool filled with cornstarch/water