

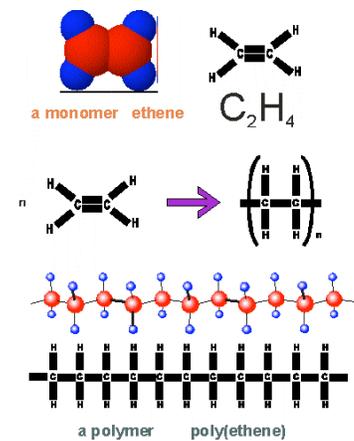
# Gak and the Non-Newtonian Fluid

## 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.

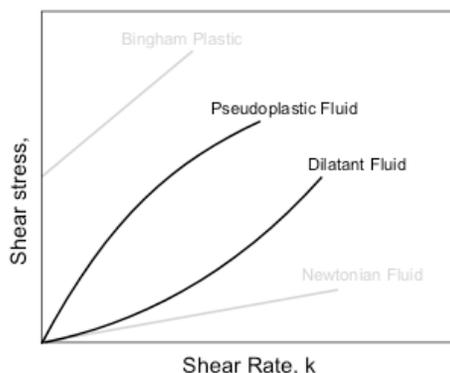
## Background

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](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 them run off  
Ketchup in a glass bottle

### **Demonstration – Pool of Cornstarch/water**

Kiddie pool of cornstarch/water.

### **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

### **Non Newtonian fluid (per group)**

Dixie cup for mixing  
Wooden stirrer  
Small plastic ziplock bag for storing  
Cornstarch  
Water

## **Procedure**

### **To prepare before the session:**

1. **About an hour before the event**, start making the Kiddie pool of Cornstarch/water. It takes at least two people and a lot of cornstarch, water and stirring to get a large enough pool that gives the WOW factor. Clean up takes a while as well – it's best to have this pool outside close to a hose and drain.
2. Prepare the Borax/water and glue/water solutions in bulk a head of time and arrange materials to be handed out smoothly.

### **During session**

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.

3. 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, stirrer, glue solution. 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?***

c. Hand out small Ziplock bags so they can take home their new polymer.

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.

a. Pass out cups, cornstarch and water (cornstarch:water is 4:1) and stirrers.

b. Have the families slowly stir the mixture together adding half the quantities at a time. When the mixture is ready, have the families poke at their mixture with force then with little force to see the change in viscosity.

c. After they have had fun with their little sample, take them outside for the last 8 minutes or so of the session to demonstrate large scale the non Newtonian fluid. Hopefully you can jump or run on the mixture. The kids will want to then stick their hands into the large mush. 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://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](http://www.youtube.com/watch?v=f2XQ97XHjVw) Pool filled with cornstarch/water