

Complex Fluids: the non-Newtonian fluid: Gak

Complex fluids are mixtures that have characteristics of more than one phase of matter. (solid, liquid, gas, plasmas).

The combination of BORAX, glue and water result in a substance that exhibits the properties of a solid and a liquid depending on the amount of **pressure or force applied to it**.

These types of fluids that don't behave like what we think of as "normal" fluids are called non-Newtonian fluids. Many non-Newtonian fluids are made of polymers - long chains of repeating molecules - that give the fluid unusual physical properties such as **flexibility** and **strength**.

Vocabulary

Molecule: the smallest particle of a substance that retains all the properties of the substance. A molecule is composed of one or more atoms.

Non-Newtonian Fluid: a fluid that has the characteristics of both a solid and a liquid, depending on the amount of force applied to it.

Polymer: a long-chained molecule consisting of smaller repeating molecule units (known as monomers). (See paper clips)

Linear Polymer: the molecular units are linked in a linear fashion. (Spaghetti)

Cross-linked Polymer: adjacent linear molecular chains are connected together.

EXPERIMENT:

Materials:	Borax powder	Water	White glue
Food coloring	Spoon	Cups	Bowl

1. **Make a saturated Borax solution** by stirring one tablespoon of Borax powder into one cup of water. (A solution is saturated when the substance that they are mixing in no longer dissolves.) Set the solution aside.

2. **Pour 4 oz glue into a bowl.** Describe the characteristics of the glue.

Glue is a type of polymer consisting of long chains of repeating molecules.

Fill empty glue container half full of water, lightly shake and add the water to the bowl. Add a drops of food coloring (optional). How does the mixture feel when stirred?

3. **What will happen if you combine this mixture with the saturated Borax solution?**

Stir one teaspoon of the saturated Borax solution into the glue & water mixture. *Stir continually.* Keep adding Borax by the teaspoonful until you see a change in the liquid.

How did the mixture change? Touch the mixture and describe what it feels like.

4. If the mixture feels sticky, try adding a little more Borax solution.

If the mixture feels very wet and slippery (and no longer runny), remove it from the cup and knead it until it is a stretchy, gooey substance.

If the mixture is stringy and not malleable, try adding a little more glue.

5. Perform various actions on the Gak (snap it, bounce it, tear it, squeeze it, hold it gently, etc.)

Does the Gak have the characteristics of a **solid** or a **liquid**?

What's Happening?

White glue is a linear polymer, made up of millions of long strands of molecules linked together like chains. The chains of glue molecules are able to slip and slide freely over one another like strands of cooked spaghetti; however, they are so long that they tangle together, which gives glue its thick consistency. When added to the glue, Borax links the long strands of glue molecules together like a net to form a cross-linked polymer commonly called Gak.

Scientists believe that it is the interaction between these chains that causes this non-Newtonian fluid to react like a **solid** (to hard or fast pressure) and like a **liquid** (to slow, even pressure).

Think about it.

Depending on its molecular makeup, a polymer can be soft or hard, flexible or stiff, durable or fragile. What are other non-Newtonian fluids in our everyday life?

Natural polymers include wool, hair, silk, rubber, and sand

Synthetic polymers include nylon, Teflon, Formica, and rubber silicone.

Next Generation Science Standards

Science & Engineering Practices Appendix F

1.a.6 (Grades: 6-8): Ask questions that can be investigated within the scope of the classroom, outdoors environment, and museums and other public facilities with available resources and, when appropriate, frame a hypothesis based on observations and scientific principles

3.a (Grades: 6-8): Plan an investigation individually and collaboratively, and in the design: identify independent and dependent variables and controls, what tools are needed to do the gathering, how measurements will be recorded, and how many data are needed to support a claim.

3.b (Grades: 6-8): Conduct an investigation and/or evaluate and/or revise the experimental design to produce data to serve as the basis for evidence that meet the goals of the investigation.