*The Society of Rheology*
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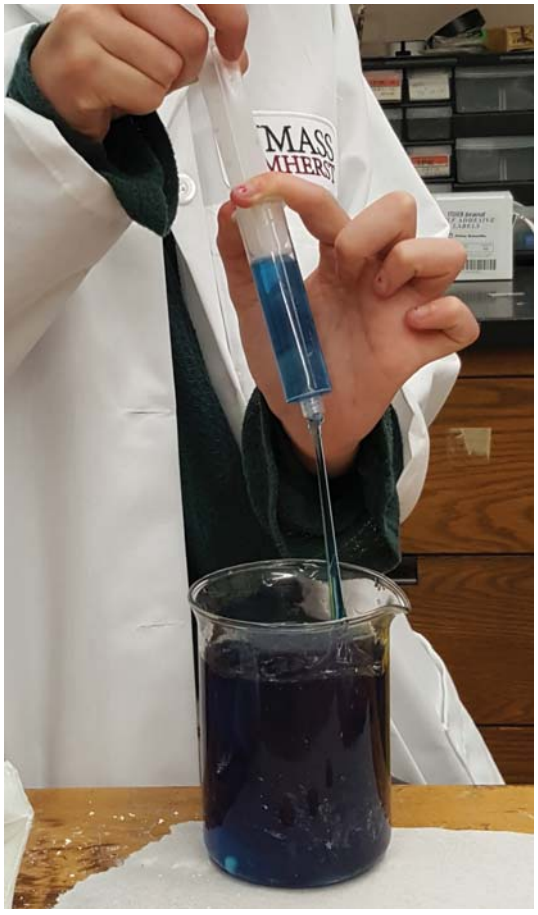
# Tubeless Siphon and Die Swell

In this demo, we explore more intriguing behaviors of non-Newtonian liquids. The super slippery elastic liquid goo, which is made up of long entangled polymer chains, will be performing a number of astounding feats that would be impossible to repeat using only water. Here, using a simple syringe, we will create a tubeless syphon which can empty a glass of goo without touching the surface of the liquid. Once in the syringe, we will show you just how badly the goo wants to get out. As we depress the plunger, a jet of goo will form that will swell to three or four times the size of the opening of the syringe. Both phenomena are related to the elastic nature of the fluid. Now that's something water will never understand. But you can!



## What you will need to get started

- Gravi-Goo from Steve Spangler Science
- Water
- Food coloring
- 0.5L or 1.0L bottle with screw top
- Clear plastic 8oz cups
- Probes – 60ml syringe without tips
- Clean up - Paper towels and a littl water

## Making the Goo

1. Mix 5g of the Gravi-Goo with 150ml of water and let it stand for an hour.

2. Add some food coloring for fun.

3. The Goo can be stored in the bottles.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## Let's experiment!

1. Pour some of the Goo into a plastic cup. Now take a syringe and try to suck some of the Goo into it. While doing this, lift the syringe above the surface of the Goo slowly. What do you see happening?

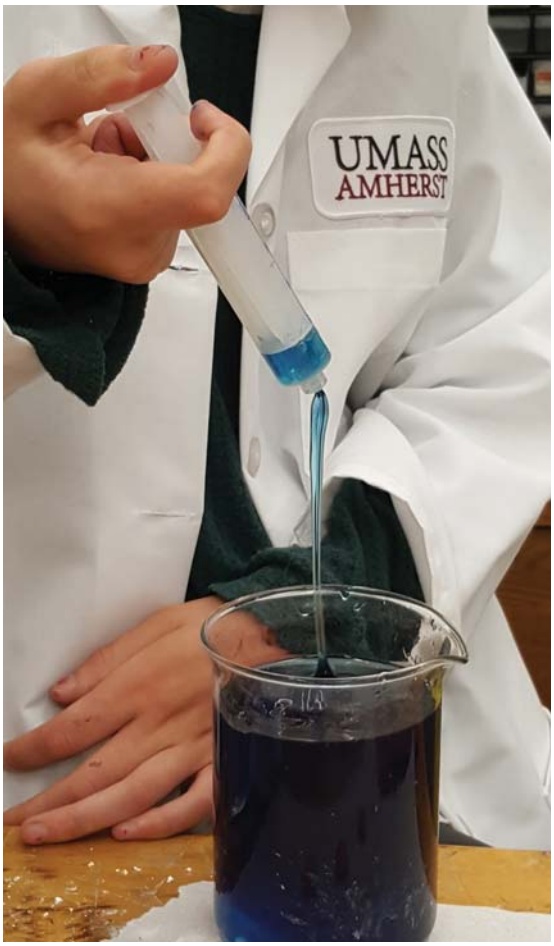
2. Repeat the above step a few times while sucking the Goo into the syringe at different speeds. How high can you take the syringe out of the Goo? Can you raise the syringe higher if you suck the Goo in faster?

3. Can you do the same thing with water? Try it.

4. Now when the syringe is full of the Goo, force the Goo out of the syringe quickly. What shape does the Goo have while coming out of the syringe? How does its width compare to the exit diameter of the syringe?

5. Do you think that would happen with water? Try it.

6. Repeat the above step by changing the speed with which you push the Goo out of the syringe. Does the shape of the Goo coming out change with the speed at which it is pushed out?





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## How does it work?

This demo is another way to observe the effects of an entagled polymer in a non-Newtonian liquid. To create a tubeless siphon, the siphon is first started by inserting the syringe nozzle into the gooey non-Newtonian liquid. The syringe nozzle is then raised above the free surface of the fluid, and instead of the fluid flow stopping, the siphoning action continues. This phenomenon is due to the elasticity of the entangled network of polymers in the liquid. Once the siphon has been started, that is, part of the entangled polymers have been pulled into the syringe, the remaining long chains of polymers continue to be pulled into the syringe because of the elastic stresses generated in the direction of fluid flow. As a result, the Goo appears to oppose gravity and forms a tubeless siphon.

The die swell effect can be observed as the Goo is rapidly driven out of the syringe. In this instance, the coiled polymer network is compressed inside the syringe nozzle and as soon as they are released through the nozzle, the polymers behave like an elastic band and snap into a relaxed configuration. This causes a bulge to appear near the tip of the nozzle. This die swell effect depends on the length of the nozzle and also the speed at which the liquid is pushed through it. The faster the flow or the narrower the nozzle, the more die swell you will observe.