Introduction

According to Wikipedia, gels are “jelly-like materials that can have properties ranging from soft and weak to hard and tough.” They are found in almost all homes in different forms. For example, there is probably some hair gel in your bathroom. If you are wearing contact lenses, then there is a gel sitting on your eyeball. In biology labs, scientists can run an electrical current through gels in order to separate DNA or protein based on their size. Cells can be grown on gels that are comprised of various amounts of collagen.

Gels have many important physical characteristics. One interesting mechanical property of gels is their compliance, or stiffness. Obviously, hair gel is less stiff than contact lenses. In the growing field of mechanobiology, researchers study how cells respond to their mechanical environment by culturing them on soft or stiff gels. This kind of research will help to understand how to fight diseases that are caused by altered mechanical environments such as atherosclerosis, cancer, and cirrhosis. To make gels that have different stiffnesses, scientists vary the ratio of polymer to its crosslinker, which is a molecule that bonds one polymer to the next.

Objective

In this lab, we will make gels of varying compliances by altering the ratios of a polymer with its crosslinker and examine their physical characteristics.

Materials

- 5 zip lock bags
- A cup of “solution A”
- A cup of “solution B”
- Plastic teaspoons
- Permanent marker
- Food coloring
Procedure

1. By varying the ratio of polymer to crosslinker, gel can be made with different compliances. To start off, make a gel that has a 4 to 1 ratio of solution A to solution B. To accomplish this, label a zip lock bag with “4:1.” Add 4 teaspoons of solution A to the bag. Then add 1 teaspoon of solution B to the bag. Zip up the bag and mix thoroughly with your fingers. After a few minutes, you should get a gel. Take this out of the bag and kneed with your hands. Write down some properties of the gel (stiffness, stickiness, bounciness, elasticity, etc.)

2. What happens when you pull the gels apart slowly?

What happens when you pull the gels apart quickly?

Think about the molecular structure of the gel. How do the polymer chains rearrange as you pull the gel apart slowly?

How is this different when you pull the gel apart quickly?
How does molecular rearrangement of polymer chains affect the gel's mechanical properties?

3. Make a ball out of the gel and let it sit on the table for a few minutes. What happens?

Would you characterize your gel as a solid or liquid? Why?

4. From this point on, you will be designing an experiment. Make two to four new gels with different ratios of solution A to solution B. Do not go lower than a 2:1 ratio or higher than a 10:1 ratio or you will not get a nice gel to play with. Remember to label your zip lock bags with the correct ratios! Compare the properties of your new gels to the 4:1 ratio gel.

5. Based on your observations, how does adding more/less solution A affect gel properties?
6. In science, it is very important to quantify results by using numbers to describe and analyze data. Quantify one physical property of your gels as a function of its polymer ratio. Write down and explain the procedure of your quantification method. Create a chart or graph of this data. To get you started, a sample graph is included. In this example, how would you quantify stiffness? (Hint: you can use rulers and/or stopwatches)

\[\text{Stiffness} \quad \text{polymer ratio}\]

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7. If you were to engineer an implantable blood vessel using gels, which mechanical properties would you consider and why are they important?