Name: ____ Class period: ________

Creating a Shape Memory Polymer from Silicone-1 Caulk, with Extension: Oil and Water Separation

Pre-Lab Question

1. What does it mean for a substance to have "shape memory"?

Materials for Part 1

- Safety Glasses or Goggles
- Gloves
- 4 Plastic Cups
- Spatula
- Silicone-1 Caulk
- Corn Starch
- MiraLAX
- Food Coloring
- 3-4 weigh papers

Procedure

1. Get 4 plastic cups and 3 weigh papers.

Batch 1: Corn Starch and Silicone ("Ooogoo")

2. Take 1 of the plastic cups and measure out ~1.2 grams of corn starch. Record the exact mass of the corn starch below:

   Mass of Corn Starch: ____________ g

3. Take a 2nd cup to the fume hood to measure out ~3.0 grams of silicone-1 caulk. Record the exact mass of the silicone-1 below.

   Mass of Silicone-1 Caulk: ____________ g

4. Before leaving the fume hood, add 1 drop of food coloring to the silicone-1 caulk.
   Record color here: __________
5. Using your spatula, stir the food coloring into the caulk until it's evenly mixed.
6. Pour the corn starch into the cup with the silicone-1 caulk, and mix until it has the same composition throughout.
7. Using your spatula, scrape the ball of material onto 1 of the weigh papers, and press into a flat sheet using the spatula or another weigh paper. Write your names and class period onto the weigh paper, and set aside to dry.
8. Throw out the cup that contained the silicone-1 caulk. Use a paper towel to wipe out the cup containing the corn starch, and use a paper towel to scrape off the material on the spatula.

Batch 2: Ratio of 1:2.5 MiraLAX: Silicone

9. Re-use the cup that contained the corn starch. Measure out ~1.2 grams of MiraLAX Record the exact mass of the MiraLAX below:

Name: _______________________________________ Class period: ________

Mass of MiraLAX: ____________ g

Take your 3rd cup to the fume hood and measure out ~3.0 grams of silicone-1 caulk. Record the exact mass of the silicone-1 below.

Mass of Silicone-1 Caulk: ____________ g

10. Add 1 drop of food coloring the silicone-1. Choose a different color than you used in the first batch. Record color here: ______________
11. Stir in the food coloring to the silicone-1 until evenly distributed.
12. Pour the MiraLAX into the cup with the silicone, and mix until you have an even composition.
13. Use the spatula to scrape the ball out onto the 2nd weigh paper, and press flat. Write the ratio of MiraLAX: silicone on the weigh paper (1:2.5 MiraLAX: silicone), as well as your names and class period on the weigh paper. Then set aside to dry.

14. Throw out the cup that contained the silicone-1 caulk. Use a paper towel to wipe out the cup containing the MiraLAX, and use a paper towel to scrape off the material on the spatula.

Batch 3: Ratio of 3:1 MiraLAX: Silicone

15. Re-use the cup that contained the MiraLAX. Measure out ~6.0 grams of MiraLAX Record the exact mass of the MiraLAX below:

Mass of MiraLAX: ____________ g

Take your 3rd cup to the fume hood and measure out ~2.0 grams of silicone-1 caulk. Record the exact mass of the silicone-1 below.

Mass of Silicone-1 Caulk: ____________ g
(IMPORTANT: Make sure you have 3x as much MiraLAX as Silicone; if not, measure out more MiraLAX until you have 3x as much. New MiraLAX amount: _______ g)

16. Add 1 drop of food coloring the silicone-1. Choose a different color than either previous batch. Record color here: ______________
17. Stir in the food coloring to the silicone-1 until evenly distributed.
18. Pour the MiraLAX into the cup with the silicone, and mix until you have an even composition.
19. Use the spatula to scrape the ball out onto the 3rd weigh paper, and press flat. Write the ratio of MiraLAX: silicone on the weigh paper (3:1 MiraLAX: silicone), as well as your names and class period on the weigh paper. Then set aside to dry.
20. Clean up your lab area, throwing out the remaining cups and wiping down your spatula with a paper towel to remove the silicone.

Part 2: Testing the Shape Memory Properties

Materials

- Safety Glasses or Goggles
- Hot plate
- Scissors

Name: ____ Class period: ________

- Thermometer
- 250 mL Beakers
- Stir rod (or spatula)
- 3 binder clips
- Masking or Beaker Label Tape

Procedure

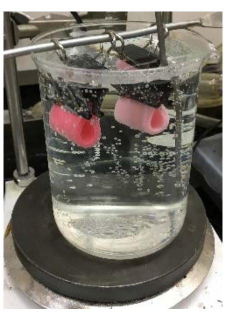
1. Fill each of the 3 beakers with 250 mL of water.
2. Place 1 beaker full of water on the hot plate, and turn the hot plate on high. Place the thermometer in the water. Heat until the water reaches 60^{o} C.
3. While you are waiting, find the three batches you prepared last class. Peel each sample off of the weigh paper. Using the scissors, trim the edges so that you have a rectangular shape.
4. Cut the 3:1 Ratio MiraLAX: Silicone sample in half.
5. Weigh one of the halves to find its mass: _______________g. Then place that half in a 250 mL beaker filled with cold water. Use the tape to label the beaker with your names and class period. Set the beaker with that sample aside to soak until next class. The other half of the 3:1 MiraLAX: Silicone sample you will use for testing today.

6. To help you remember during testing, write down the color of each batch in the table below.

Batch	Color of samples
Corn Starch: Silicone	
1:2.5 Ratio MiraLAX: Silicone	
3: 1 Ratio MiraLAX: Silicone	

7. Take each of your 3 remaining samples and bend each one in half, so that the two ends meet. Then secure with a binder clip. See photo below.

8. Once the water on the hot plate is at 60^{o} C, you are ready to begin testing. At this time, you can turn the hot plate down to a lower setting. (You don't want the water to boil, just to stay above 60^{o} C during the tests.)
9. Slide the 3 binder clips onto the stir rod, and use to suspend 1 sample from each batch (Corn starch & Silicone, 1:2.5 MiraLAX: Silicone, and 3:1 MiraLAX: Silicone) in the hot water. See example in photo below.



Name: ____ Class period: ________

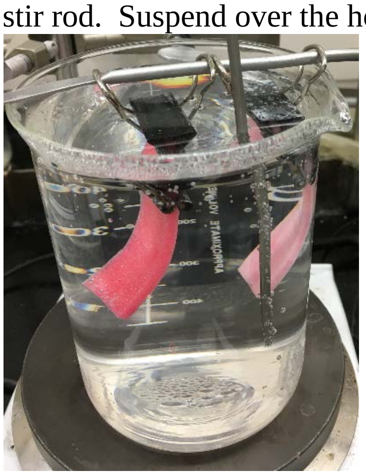
10. Keep in the hot water for 3 minutes.

11. Immediately move the stir rod with the samples to the 2^{nd} beaker of water, which should be at room temperature. Keep in the cold water for 3 minutes.

12. Remove the stir rod from hanging over the cold water beaker and place on a paper towel. Remove the binder clip from each of the 3 samples. Record your observations below.

Sample	Color of sample	Rank your samples in terms of best shape memory. (Did they retain the C-shape after the binder is removed?)	How did the texture change after being in the water?
Corn Starch: Silicone			
1:2.5 MiraLAX: Silicone			
3:1 MiraLAX: Silicone			

13. Now place one end of each sample back into the binder clip, and slide the binder clips back onto the stir rod. Suspend over the hot water beaker for 3 minutes.



Write your observations in the space below. What happens to each sample as they are heated back up above 60^{o} C?

Name: ____ Class period: ________

14. Remove from the hot water, and gently dry both samples with a paper towel.
15. Then repeat the shape memory test. Place each sample in a binder clip, so that they both form a C shape. Hang over the hot water for 2 minutes, then place immediately into the cold water for 2 minutes. Remove from the cold water, and remove the binder clip. Record your observations in the table below.

Trial 2

Sample	Color of sample	Rank your samples in terms of best shape memory. (Did they retain the C-shape after the binder is removed?)	Was there any change in the results from the 1st trial?
Corn Starch: Silicone			
1:2.5 MiraLAX: Silicone			
3:1 MiraLAX: Silicone			

16. Clean up your lab area. Make sure to wash your hands before returning to your seat.

Post Lab Questions

1. The melting point of MiraLAX is ~55^{o} C. By heating the sample above 60^{o}C, what did that cause to happen inside the mixture of MiraLAX: Silicone?

2. Why was it necessary to cool the samples before removing the binder clip?

3. Draw pictures to represent what's happening at the molecular level in the MiraLAX: Silicone sample in the 3 phases of testing (at the start, after heated, after cooled down).

4. Why do you think the results changed from trial 1 to trial 2? (Hint: what happened to the texture of the samples?)

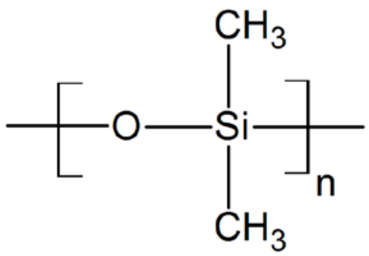
Name: ______________________________________ Class period: ________

Part 3: Mixture Separations

Pre-lab Questions

1. In the web quest, you researched different methods of separating mixtures. Last class, your lab group placed the 3:1 MiraLAX: Silicone sample in a beaker full of water to soak. This will separate the mixture using what property?

2. The monomer that forms the base of silicone is



Calculate the difference in electronegativity for each bond in the monomer.

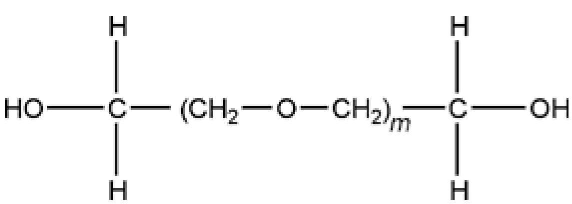
C-H ___________ Is this bond ionic, polar, or nonpolar covalent? ____________

C-Si ___________ Is this bond ionic, polar, or nonpolar covalent? ____________

Si-O ___________ Is this bond ionic, polar, or nonpolar covalent? ____________

What intermolecular forces will most affect this compound?

3. MiraLAX is polyethylene glycol with a molecular weight of 3350. The monomer that forms the base of MiraLAX is



C-H ___________ Is this bond ionic, polar, or nonpolar covalent? ____________

C-C ___________ Is this bond ionic, polar, or nonpolar covalent? ____________

C-O ___________ Is this bond ionic, polar, or nonpolar covalent? ____________

O-H ___________ Is this bond ionic, polar, or nonpolar covalent? ____________

What intermolecular forces will most affect this compound?

4. Based on the intra- and intermolecular forces, which of the two substances (MiraLAX or silicone) would you predict would dissolve in water, which we know is polar-covalent?

Name: ____ Class period: ________

Materials

- Paper towels
- 250 mL Beaker
- Food coloring
- Vegetable Oil
- Pipette
- Tweezers

Procedure

1. Remove your 3:1 MiraLAX: Silicone sample from the beaker, and drain the water. Wash and dry the beaker.
2. Using paper towels, carefully squeeze the water out of your sample, until no more water comes out on the paper towel. **Record your observations about the sample below.** a) Does it still look like a solid plastic? b) What do you notice about the surface texture?

3. Weigh your sample. Final mass of sample: _________________ g
4. Using your data from part 1 and 2 of the lab, complete the following table:

Part 1: Mass of Silicone in batch	Part 1: Mass of MiraLAX in batch	Part 1: Total Mass of batch	% Composition by mass of the MiraLAX in the original batch = $\frac{mass\ MiraLAX}{total\ mass}$	Part 2: Initial mass of the sample before soaking in water	Part 2: Calculate the mass of the MiraLAX in the sample you prepared: *multiply the % composition by the initial mass of sample*

5. Subtract the final mass of your sample from the initial mass of your sample from part 2 of the lab. Mass lost to the water = $M_I - M_F$ = ______________________ g

6. Assuming that your sample only lost MiraLAX to the water, calculate the % of MiraLAX remaining in your sample using the following formula.

$$\%\ MiraLAX\ remaining\ in\ sample = \frac{Mass\ of\ MiraLAX\ in\ batch - Mass\ lost\ to\ the\ water}{Mass\ of\ MiraLAX\ in\ batch} * 100$$

% MiraLAX remaining in your sample = ____________________ %

Name: ______________________________________ Class period: ________

7. Refill the beaker with 250 mL of water. Add 1 drop of food coloring and stir.

8. Then using the pipette, transfer enough vegetable oil to completely cover the surface of the water.

9. Drop your sample into the mixture of oil and water. Using the tweezers, move the sample about the beaker to collect oil on the surface of the material.

10. Using the tweezers, remove the sample from the beaker onto a paper towel. Carefully remove the collected oil by squeezing with the paper towel.

11. Repeat steps 5 and 6 until you've removed as much of the oil from the water as you can.

12. Clean up your lab area, including washing the beaker and tweezers.

<u>Post Lab Questions:</u>

1. For this lab, the MiraLAX was removed from the MiraLAX: Silicone mixture by passively setting in water overnight. Based on your research on mixture separation, what are 1 or 2 ways that you might be able to increase the removal of the MiraLAX from the MiraLAX: Silicone mixture?

2. How efficient was your "sponge" at separating the vegetable oil from the water?

3. Brainstorm with your lab partner to come up with 2 ways that you might be able to improve the oil and water separation technique that was used in this lab.

-
-

4. Based on your reading, which type of oil spill clean-up technique was simulated in this activity? Explain why, based on your observations in the lab.