

Penn State RET in Interdisciplinary Materials

Lesson Plan

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Preparing an Emulsion

Purpose This lab is designed to help students understand homogeneous and heterogeneous mixtures, polarity and intermolecular forces using emulsions.

Objectives

- Explain the differences between an emulsifier and a detergent.
- Identify the types of two-phase emulsions and give examples of each.
- Understand what an emulsifier is and what it is used for.
- Summarize why “oil and water don’t mix” using the idea of intermolecular forces and polarity.
- Draw a diagram to explain the emulsion made in the lab. Labeling the oil, water and emulsifier. Identify the polar and nonpolar phase and hydrophilic and hydrophobic ends of the emulsifier.
- Discuss the outcome of the “Making Mayonnaise” experiment. Explain successes and errors that occurred.

Time required

Without background article - 3 class periods (one lecture and two lab or three lab days) (~120 min)

With background article – 5 class periods (2 lecture and 3 lab day) (~200 min)

Level

High school

National Science Education Standards (High school)

- HS-PS1-3. Plan and conduct an investigation to gather evidence to compare the structure of substances at the bulk scale to infer the strength of electrical forces between particles.
- HS-PS1-5. Apply scientific principles and evidence to provide an explanation of phenomena and solve design problems, taking into account possible unanticipated effects.
- HS-PS2-6. Investigating or designing new systems or structures requires a detailed examination of the properties of different materials, the structures of different components, and connections of components to reveal the structure’s function and/or to solve a problem.
- Attraction and repulsion between electrical charges at the atomic scale explain the structure, properties, and transformations of matter, as well as the contact forces between material objects. (HS-PS2-6) (secondary to HS-PS1-1), (secondary to HS-PS1-3)

Teacher Background

Food plays a very important role in our everyday lives and students do not really think about the chemistry involved in preparing some of the foods that we eat on a daily basis. This activity will relate the somewhat challenging concept of intermolecular forces to foods that students should be familiar with. An article about emulsions will be used to explain some of the vocabulary. A discussion should occur about what students learned in the article prior to completing the lab to assess student understanding. Be sure to

incorporate the concepts of polarity and intermolecular forces.

Links to the article and recipe for mayonnaise will be given later in the lesson plan.

I intend to use this lesson as a review activity at the end of the year to prepare my students for the New York State Chemistry Regents exam.

Materials

For **each** group:

- 1 egg
- Salt
- Dry mustard
- Lemon juice
- White vinegar
- Oil (olive, canola)
- Measuring spoons ($\frac{1}{2}$ teaspoon, teaspoon, tablespoon)
- Measuring cup (1 cup)
- Food processor
- Eye dropper (brand new)
- Container with lid to store mayonnaise
- Spatula
- Paper towels
- Goggles
- Gloves
- Aprons (optional)
- Bowl (optional – to gather ingredients then place in the food processor)

Advance Preparation

You can purchase most of the materials at the local grocery store or see if students are willing to bring some materials from home (measuring cups, measuring spoons, food processors). If you have a FACS classroom with a kitchen, it might be best to try to complete the lab activity in that room if available. Talk to faculty and administration to arrange a classroom change.

Safety Information

Goggles should be worn to protect students' eyes from "flying" mayonnaise. Gloves should be worn to not contaminate the mayonnaise if it is going to be consumed by students. Aprons would be helpful to prevent students from getting oil or mayonnaise on their clothes.

Teaching Strategies

If students have not discussed emulsions previously, it might be a good idea to have them read and discuss the article about emulsions (see Resources Section). Understanding the vocabulary and components of the emulsion will help students understand "WHY" they are doing the lab. A worksheet is attached with questions based on the article to complete individually or in a group and discuss in small groups or as a whole class.

Students should be familiar with polarity of molecules, intermolecular forces and homogeneous

and heterogeneous mixtures. You may want to review these concepts as well to make sure students understand the “WHY” behind completing the lab.

Discussing the types of fatty acids present in the different oils will allow students to make a prediction about the oil that will make the thickest mayo. (See “Resources” section). You can also have students draw the structures if organic chemistry has been discussed previously.

The lab would be best performed in groups. Have each group choose a different oil to use to make the mayonnaise. Students can compare observations about the thickness of the mayonnaise. If performing the lab in a space where eating is allowed, you can have students taste test the mayo also to evaluate the flavor.

The results of the lab may not go as planned. Students need to be patient when adding the oil or the mayo with “break” and not thicken. This is not necessarily a bad outcome. Students will be able to see that experiments are not all successful but not a failure. Discuss what students should do to improve the experiment if given the opportunity to do it again.

Resources:

You may wish to use these resources either as background or as a resource for students to use in their inquiry-based design.

Emulsion article link:

<https://www.aocs.org/stay-informed/inform-magazine/featured-articles/emulsions-making-oil-and-water-mix-april-2014?SSO=True>

Fatty Acid Composition of Different Vegetable oils

<https://thepaleodiet.com/vegetable-oil-fatty-acid-composition/>

Home-made Mayonnaise link:

<https://www.thegraciouswife.com/homemade-mayo-recipe/>

Directions for the activities:

Optional Emulsions Article Lecture Day 1

- Hand out emulsion article or have students open article (<https://www.aocs.org/stay-informed/inform-magazine/featured-articles/emulsions-making-oil-and-water-mix-april-2014?SSO=True>) on tablets. (2 min)
- Ask students to read the article and take notes or highlight important information (35 min)
 - You can also assign the article reading for homework

Optional Emulsions Article Lecture Day 2

- Ask students to volunteer something that they learned about from the article (5-10 min)
 - This is a good opportunity to see if students understood the vocabulary and the purpose of the article.
- Split students up in groups to discuss and answer the article questions provided on Page 13.
 - Have questions on a Jamboard or on large paper for students to add their group answers to each question. (20-25 min)

- Discuss group answers to each question and address misunderstandings prior to starting the emulsion lab. (5 – 10 min)
- (Alternative) You can also hand out the questions to individuals to have them complete as an assignment. (30 min)
 - The answers to the questions should be discussed or graded for assessment of student understanding prior to starting the emulsion lab. (10 min)

Lab Day 1- Lab prep

If not reading the emulsion article, discuss what an emulsion and an emulsifier are and what they are used in and for. (10 min)

For all:

Review polarity, intermolecular forces and homogeneous and heterogeneous mixtures. (10 min)

Hand out lab and go over Introduction and discuss oils available for the experiment. (5 min)

Ask students to choose an oil. **Depending on class size max the number of students per oil.** (2 min)

Have students write their prediction based on the oil they will use and the other oils available (3 min)

Have students get into groups to breakdown the procedure to decide who will do which tasks. (10-20 min)

Lab Day 2 – Perform Experiment

Have students get in groups and remind them of the safety procedures and refresh the roles in the group. (5 min)

Procedure for Making Mayo (35 min)

1. Put on goggles, gloves and apron (optional).
2. Gather ingredients to make mayonnaise. **You can set up stations for each ingredient for students to measure in a bowl and then place in the food processor or have enough materials for each group to work at their own station. Have different students be responsible for each ingredient.**
3. Lay down paper towels on your workspace for possible spills. **Preparing for spills that are bound to happen is best than trying to scramble after a spill occurs.**
4. Set up and plug in food processor. **You may only have access to one food processor for the class. Allow extra time to clean the processor between each batch.**
5. Add all ingredients EXCEPT oil to the food processor. **Put a sign at each station to remind students not to add oil with the other ingredients or they will never make mayo.**
6. Process the ingredients for about 10 seconds, or until creamy. **Ask one student to keep time in each group.**
7. With the food processor still running, begin to SLOWLY add the oil. Start with just a few drops. **Use eye dropper for this step.**
8. Wait 30 seconds and add a few more drops.
9. Continue this process until you see that the mixture is starting to thicken.
10. When the mixture begins to thicken you can begin pouring the oil in a steady, THIN stream. (Pouring too much, too fast will break the mayo and make it runny). Stop pouring every once in a while, to check that the mayo has enough time to incorporate all the oil before continuing. **Remind students to take their time or they will “break” the mayo.**
11. Record observations of the mayo in the data table provided. Observe color, odor, consistency.
12. Once all the oil is incorporated, use the spatula to scoop the mayo into the container and cover.
13. Store in the fridge until ready to use. **You can test thickness by placing an object (toothpick) in each**

sample to see how long it “stands up” or put some on a spoon and turn it upside down to test stability. Taste testing is also optional depending on where the experiment is being performed.

14. Unplug the food processor.
15. Wash measuring cup, spoons, spatula, and food processor parts.
16. Put materials away and wash workspace to avoid staining clothing with oil.
17. Throw gloves away and wash your hands.

Lab Day 3

Procedure for Thickness Testing: (20 min)

1. Remove mayo from the fridge.
2. Place 4 Tbs of one mayo on a small plate or in a small bowl. Label plate or bowl with oil type.
3. Take one toothpick and place it upright in the center of the mayo. Start the stopwatch.
4. Record the time it takes the toothpick to fall over in seconds. Record the value in Table 2.
5. Convert time to seconds. Show work in Table 3 and place seconds value in Table 2.
6. Repeat for the remaining samples.
7. Throw toothpicks and used mayo in the trash.
8. Return any unused mayo to the fridge.
9. Wash tablespoon and bowls and return.
10. Wash your hands and wipe down work area.

Lab calculations, questions and conclusion (20 min)

Have each student complete calculations, work on lab questions and write a conclusion discussing their prediction and whether it was correct or not. **Make sure they give a reason for why they were correct or incorrect. If their mayo was broken, have them explain what went wrong during the lab.** Have students discuss ways to improve the lab. **Should different oils be used? Should egg whites or different types of eggs be used?**

Cleanup

Wash and dry all the measuring spoons, cup, spatula, bowl, and food processor pieces. Make sure students wash their hands after the experiment. Wipe down work area and dispose of paper towels in the trash.

Dispose of unused and used mayo in the trash after testing. Clean mayo container and lid.

Preparing an Emulsion

Introduction

Chemistry is EVERYWHERE, from the foods you eat to the technology you use every day. Today in lab, we are going to make mayonnaise, an emulsion. We will be using different oils to prepare the emulsion to determine if the type of oil affects the overall thickness, consistency and taste of the mayo. Each group will make a batch of mayonnaise that we will test for thickness and taste. Based on what you read and learned about emulsions, predict which oil will create the thickest mayonnaise and give a scientific reason “why”.

Make a Prediction:

Materials

- Goggles
- Gloves
- Apron (optional)
- 1 egg
- 1 tsp salt
- ½ tsp dry mustard
- 2 tsp lemon juice
- 2 Tbs white vinegar
- 1 cup oil (olive, canola, etc)
- Food processor
- Eye dropper
- Container with lid
- Spatula
- Paper towels
- Bowl for gathering ingredients
- Toothpicks or small objects to test thickness
- Small plates or bowls
- Stopwatch

Procedure to Make Mayo:

1. Put on goggles, gloves and apron (optional).
2. Gather ingredients to make mayonnaise.
3. Lay down paper towels on your workspace for possible spills.
4. Set up and plug in food processor.
5. Add all ingredients EXCEPT oil to the food processor.
6. Process the ingredients for about 10 seconds, or until creamy.
7. With the food processor still running, begin to SLOWLY add the oil. Start with just a few drops.
8. Wait 30 seconds and add a few more drops.
9. Continue this process until you see that the mixture is starting to thicken.
10. When the mixture begins to thicken you can begin pouring the oil in a steady, THIN stream. (Pouring too much, too fast will break the mayo and make it runny). Stop pouring every once in a while, to check that the mayo has enough time to incorporate all the oil before continuing.
11. Once all the oil is incorporated, use the spatula to scoop the mayo into the container and cover.
12. Record observations of the mayo in Table 1 provided. Observe color, odor, consistency and taste.
13. Store in the fridge until ready to use for thickness data.
14. Unplug the food processor.

15. Wash measuring cup, spoons, spatula, and food processor parts.
16. Put all materials away and wash workspace to avoid staining clothing with oil.

Procedure for Thickness Testing:

1. Remove mayo from the fridge.
2. Place 4 Tbs of one mayo on a small plate or in a small bowl. Label plate or bowl with oil type.
3. Take one toothpick and place it upright in the center of the mayo. Start the stopwatch.
4. Record the time it takes the toothpick to fall over in seconds. Record the value in Table 2.
5. Convert time to seconds. Show work in Table 3 and place seconds value in Table 2.
6. Repeat for the remaining samples.
7. Throw toothpicks and used mayo in the trash.
8. Return any unused mayo to the fridge.
9. Wash tablespoon and bowls and return.
10. Wash your hands and wipe down work area.

Record Your Observations:

Table 1: Making the Mayo

Oil	Color	Odor	Consistency	Taste

Table 2: Thickness Testing:

Oil	Stopwatch time (min/sec)	Total Time (sec)

Show calculation for converting time to seconds for each oil in Table 3:

Example: Safflower oil

Stopwatch time = 6 min 15 sec

$$\begin{array}{r|l} 6 \text{ min} & 60 \text{ sec} \\ \hline 1 & 1 \text{ min} \end{array} = 360 \text{ sec} + 15 \text{ sec} = 375 \text{ sec}$$

Table 3: Time Conversions

Oil: _____
Conversion:

Oil: _____
Conversion:

Oil: _____
Conversion:

Oil: _____
Conversion:

Analyze the Results:

Use the following data table to rank each mayonnaise based on the observations in Table 1 and Table 2. Be sure to include reasonings for your rank based on the data collected. (This will help you write your conclusion) **Rank of 1 = BEST** **Rank of 4 = WORST**

Rank	Mayo oil - Taste	Evidence for Taste Rank	Mayo oil - Thickness	Evidence for Thickness Rank
1				
2				
3				
4				

Lab Questions:

1. In terms of polarity and intermolecular forces, explain why a mixture of oil and water is considered heterogeneous?

2. Mayonnaise is an example what type of simple emulsion? _____

3. Why is an emulsifier needed to make mayonnaise? Explain in detail.

4. Draw a diagram to explain the emulsion made in the lab. Labeling the oil, water and emulsifier. Identify the polar and nonpolar phase and hydrophilic and hydrophobic ends of the emulsifier.

Conclusion:

Write a conclusion in complete sentences with paragraphs and include the following:

- Restate prediction
- Explain if your prediction is correct or not using data and observations from the experiment to support your answer.
- Discuss ways to improve the lab and any issue you had performing the experiment.

Assessment and rubrics:

Learning outcomes:

1. Students will demonstrate an understanding of the methods scientists use to explore natural phenomena, including observation, hypothesis development, measurement and data collection, experimentation, evaluation of evidence, and employment of mathematical analysis

Scientific Method Indicators	Meets or exceeds Expectations A student will:	Does not meet expectations A student will:
Observation and hypothesis development	Recognize a hypothesis. Understand the relationship between observation and hypothesis	Fail to recognize a hypothesis and/or fail to understand the relationship between observation and hypothesis
Experimentation and methods	Understand the need for multiple trials. Understand the experimental design of a given experiment.	Fail to understand the need for multiple trials and/or fail to understand the experimental design of a given experiment.
Data collection and measurement	Collect data in a reliable manner using proper measurement technique. Record data accurately and neatly.	Fail to collect data in a reliable manner using proper measurement technique and/or fail to record data accurately and neatly.
Data representation	Organized data in a table and/or graph with appropriate labels.	Fail to organize data in a table and/or graph with appropriate labels.
Data analysis	Use appropriate mathematical analysis.	Fail to use appropriate mathematical analysis.
Drawing conclusions using scientific concepts	Draw conclusions that relate to the original hypothesis and either support or reject the hypothesis. Apply appropriate scientific concepts in a discussion of the results.	Fail to draw conclusions that relate to the original hypothesis and either support or reject the hypothesis and/or fail to apply appropriate scientific concepts in a discussion of the results.

Possible Emulsion Reading Questions:

1. Define emulsion and emulsifier.
2. Name the two types of simple emulsions.
3. Explain the difference between hydrophilic and hydrophobic head groups on an emulsifier in terms of polarity.
4. Explain, in detail, the three types of emulsifiers.
5. What is lecithin and what is it used for?
6. What are the common emulsifiers used in food?
7. Explain, with detail from the reading, **two** other ways emulsions can be used in products besides food.
8. What is a surfactant?
9. How is an emulsifier different than a detergent?