There's a lot of corn in the Midwest but can we use it to fly?

Grade Levels: 6-9
Lesson Length: Part III Testing Biodiesel 1-2 class periods

Problem Challenge: **There is a lot of corn in the Midwest but can we use it to fly?**

An effect of global climate change is that the Midwest is now isolated from the rest of world. Your team of scientists needs to find a way to provide sustainable fuel sources for transportation because there is no more gasoline. Without fuel, there is no way to get water, food, and medical supplies around the region.

Fortunately, there is a lot of wind, a lot of good soil, plenty of sun in the summer, and big bodies of water. But is there anything that will power a car or an airplane? Is there anything that will move stuff? And will it do these things without producing the greenhouse gases (GHG) that make climate change even worse?

Lesson Overview

Part III Testing Biodiesel Lab A Spot Testing, Lab B Viscosity
After looking at and analyzing data in Part I, students reviewed energy concepts and used lab techniques to make biodiesel fuel in Part II. Now they will test and identify properties of several fuels. Fuel data will inform students as they work in teams or pairs to propose solutions to the Midwest's transportation problems. Students want to find a transportation fuel with low CO_2 emissions. They discovered earlier that plants can be converted into fuels and that the process is not difficult.

Standards

NGSS-2013.MS-ETS1-1 and HS-ETS1-1

- Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and the natural environment that may limit possible solutions. (MS)
- Analyze a major global challenge to specify qualitative and quantitative criteria and constraints for solutions that account for societal needs and wants. (HS)

Objectives

- Students will describe and interpret graphic information.
- Students will analyze characteristic properties of fuels.

- Students will synthesize data from different sources to reach conclusions.
- Students will relate viscosity to carbon density.

PART III: TESTING BIODIESEL
How Does Biodiesel Compare with Other Fuels?

Materials for Spotting Test Lab

**SAFETY ALERT:** Review appropriate lab attire requirements with students. If a ventilation hood is available, place the stations for the gasoline and kerosene samples under the hood. Be sure that this learning activity is performed in a well-ventilated area. Instruct students to cover the samples (with cap, plastic wrap, or Parafilm®) after each use to keep the amount of fuel vapor released to a minimum. Remind students not to sniff the substances. Demonstrate the wafting technique to determine odor, but discourage students from breathing in any of the fuel vapors. Also, fuels should not be stored in beakers or dropper bottles. Instead, they should be returned to proper storage containers and locations at the completion of this lab.

Per Class –

- Gather small samples (student groups will only need a drop or two of each substance) of fuels such as:
    - Methanol
    - Ethanol
    - Propanol
    - Butanol
    - Paraffin (lamp oil) or kerosene (jet fuel)
    - Gasoline
    - Biodiesel(s) produced by students
  - Gather small samples of liquid feedstock such as:
    - Canola oil
    - Vegetable (soy) oil
    - Corn oil
    - Peanut oil
    - Water for a reference
  - 1 or more small beakers (50 mL) or dropper bottles for each substance
  - 1 or more droppers for each substance
  - Parafilm® (or plastic cling wrap) to cover beakers when not in use, unless using dropper bottles or bottles with lids
  - Labels and permanent fine-tipped markers or china markers to label beakers or bottles
  - Heavy weight paper and broad-tipped markers to make tent-card signs with substance names

- At least one eye dropper for each sample
- 1 or more digital cameras

Note: It is best to use glass containers and droppers, because biodiesel erodes many plastics and makes them gummy.

Per Student –

- Student journal and/or Copies of Student Page: Testing Biodiesel Spotting Test (see p.15)
- Gloves
- Goggles
- Lab apron

Per Group of 2-4 Students –

- Copies of Student Page: Materials – Spotting Test (see pp. 13)
- Copies of Student Page: Procedure – Spotting Test (see pp.14)
- Spotting paper – a source of soft paper [at least 8.5"x 11" (preferably larger), single-layered, off-white or brown – do not use copy paper or paper towels but something in-between these textures]. Craft paper, grocery bags, and parcel-wraps work well for spotting.
- Parchment paper (or waxed paper or foil) to place under the spotting paper (cut to approximately same size as the spotting paper)
- Ruler for drawing a sampling matrix – optional
- Pencil or fine-tipped permanent marker

Materials for Viscosity Test Lab

(*Note that these instructions are for glass pipettes; you can use big straws or acetate sheets instead, just modify materials and procedure accordingly. If students will test viscosity using acetate sheets raised to an angle that allows flow, practice this technique in advance.*)

- Copies of Student Page: How does Biodiesel Compare to Other Fuels? Viscosity Tests (1 per student) pp. 18-19
- Copies of Student Page: Materials – Testing Biodiesel and Other Fuels Viscosity Tests (p.16)
- Copies of Student Page: Procedure – How does Biodiesel Compare to Other Fuels? Viscosity Tests (pp. 17)
- 5–10 10 mL glass serological pipettes (1 per fluid), labeled and filled with 3 to 6 fuel samples (especially the three asterisked fuels)
  - Ethanol*
  - Biodiesel*
  - Jet fuel (Kerosene)*
  - Butanol
  - Diesel

    - Gasoline
- Oil Samples (2 to 4)
    - Canola Oil
    - Corn Oil
    - Peanut Oil
    - Vegetable (soy) Oil
    - Motor Oil
- Water (for reference)

Materials for Viscosity Test

This is an air bubble race. Big clear straws (bubble tea variety) will work if you do not have a supply of glass serological pipettes. The following directions are for using glass pipettes. The modification for straws would be to seal up the ends by bending them and then taping.

- 5–10 10 mL glass serological pipettes (1 per fluid)
- Disposable pipettes (1 per fluid for removing substances from containers)
- glue gun
- glue sticks
- masking tape
- scissors
- Fine-tipped permanent marker or ballpoint pen.

Teacher Set-up and Preparation

Print copies for students:

- Student Page: How does Biodiesel Compare to Other Fuels? Spotting Tests (1 per student) p. 15
- Student Page: How does Biodiesel Compare to Other Fuels? Viscosity Tests (1 per student) pp. 18-19
- Student Page: Biodiesel and other Fuel Properties (if not already done) p. 14 in Part II (1 per student)
- Student Handout Materials – Viscosity Testing (1 per group) p. 16
- Student Handout Procedure – Viscosity Testing (1 per group) p. 17

Spotting Test Lab Set-Up

Set up the sampling stations for the spotting tests.

1. Dispense 15 mL of each fuel in a small dropper bottle, a small bottle with a cap, or small beaker covered with Parafilm® (or plastic wrap).
2. Label each container with the name of the substance it contains, and create tent-cards with the sample names for each station. Provide an eye dropper for each station. (For larger classes, provide more than one sample set up for a substance at each station.)
3. Cut enough pieces of large brown or off-white paper for each group to have one to use for the spotting test (at least 8.5 by 11 inches).

4. Collect enough markers for the students to draw lines on their paper and label the cells where they will put their samples.

Viscosity Test Lab Set-Up
To make the tubes for the air bubble race test for viscosity, obtain a variety of fluids from the list above to test, including ethanol, biodiesel, jet fuel (or kerosene), and at least one plant-based oil. It would make sense to use the same fluids used for the fuel spot test, though you will likely use fewer types for this test.

1. Use a hot glue gun to seal up the tip (narrow end) of the serological pipettes with glue. Allow several minutes for the glue to dry completely.
2. Using a clean, disposable pipette for each kind of sample fluid, fill the pipettes to 1cm from the top.
3. Use a hot glue gun to seal the open end of the pipette with a cap of glue. It may take a few applications of glue to completely seal the pipette.
4. Allow the glue to dry, then check for leaks and fix as needed.
5. Wrap masking tape around the top portion of the pipettes to create a label. Then use a fine-tipped permanent or ballpoint pen to label each of the pipettes with the appropriate names of the fluids.

Teacher Strategy: Making a set of glass pipettes with all needed fluids for each group is an option.

Accessing Students' Prior Knowledge
In this activity, the students will be conducting several tests to discover more about the properties of different fuels. They will do this by completing two investigations: Spotting Test and Viscosity Test with various fuels. If they have not already recorded properties of substances during the making of biodiesel in Part II, learners can do that now as well.

Spotting Test – the simple fuel spotting test provides a way for students to gain a firsthand sense of fuel properties, such as viscosity, volatility, oiliness, heaviness (paper residue), and the tendency to vaporize.

Ask students to predict how the fuel or oil spots will compare for the substances provided. Ask students to explain their predictions. Remind students to record their hypotheses, reasoning, and observations in their journals and/or on the student page provided for the lab.

In the Viscosity Testing investigation, students will compare the relative viscosities of various fuel types, including biodiesel. Ask students to predict how the viscosities will compare for the substances provided and why. Be sure the students explain their reasoning. Again, use a journal or the student page for the lab (see pp. 18-19).

Exploring the Phenomenon: Laboratory Experience

Spotting Test (Lab A)

1. Arrange the students in groups of 2-4.
2. Distribute the student pages for the materials and procedure for Spotting Tests. Allow a few minutes for students to review the lab and then ask if there are any questions.

   > ***Teacher Strategy:*** Students can list the important safety precautions that they must take throughout this lab and then elaborate on the safety procedures if needed. Make sure to highlight safety in discussion at this point.

3. After addressing any questions, review the samples available for testing and where the stations are located. Remind students to cover the samples (with cap, plastic wrap, or Parafilm®) after each use.
4. Ask students: Why are we including water in the spotting test? (*Water is a good reference sample, because we know what to expect. It serves as a control for this qualitative investigation.*)
5. Provide a large sheet of brown or off-white soft paper to each group for the spotting tests. Direct them to draw lines or fold seams into the paper to create a matrix (with approximately equal-sized rectangles, or cells). The number of cells in the matrix will depend on the number of different samples tested.
6. Tell the students to use a pencil or a fine-tipped permanent marker to write the names of the samples being tested in their appropriate cells. Also be sure lab teams write their names on spotting papers.

   Once the paper is folded and labeled it might look like this:

Student Names:		
Biodiesel	Canola Oil	Ethanol
Kerosene	Motor Oil	Water

7. Provide each group with a similar-sized piece of waxed or parchment paper to place behind the spotting paper during testing so that the samples do not bleed onto other surfaces.
8. To perform the spotting tests, direct groups to move to different stations and use the droppers provided to place 3 drops on top of each other in the appropriately labeled cell.
9. Facilitate the rotation of student groups to the next station.

10. When all fuels have been spotted, place the spotting papers in a hood or well-ventilated area to dry. Set a timer so that the students can observe the spotting tests after 5 and 20 minutes.
11. Remind the students at 5 and at 20 minutes to outline the spots with pencil and take a photo of the spotting papers. (Students may choose to take more photos at regular intervals.)

Making Sense

Have students compare the results for different substances, compare results across groups, and compare their results to their predictions. Remind them to use their journals to record their observations, results, discussions, and conclusions. Some possible prompts include "Was your prediction correct?" and "Did the results support or reject your hypothesis?"

- What might a spot that evaporated quickly indicate about that substance? What makes you say that? Answers such as "the fuel is lighter," "the chemicals go into the air easily," or "the material has fewer carbon atoms," are not chemically sophisticated but are essentially true and are a good starting place.
- What might the relative darkness or spread of these spots tell you about these substances? What makes you say that? (*made of different materials, heavier, more carbons, oilier, attract dust and dirt, spread more, lighter or smaller molecules, wind, heat*)
- Which fuels come from petroleum and which come from plants? (*For the example given: canola and biodiesel come from plants, diesel, Jet1A, and butanol* come from petroleum products. *Note: Some butanols are biofuels, produced from plants or bacteria.*)

Allow students to observe the spot sheets, again, at 24, 48 and 72 hours, if time permits.

- Ask whether anything has changed over time. (*The dark spots have spread further. Light spots may have completely spread-out or may have evaporated.*)
- Remind students to record their observations and responses in their journals. Encourage students to look again at the fuel spotting papers from other teams before reaching a final conclusion. Guide them to record their observations and thinking in their journals and to share observations and discuss their thinking with other groups.
- Ask if they notice any other patterns or if they can make categories or generalizations based on the observations. (*Petroleum-based fuels spot lighter and disappear sooner. Oil-based fuels spot darker and last longer.*)
- Ask if there is a relationship between the number of carbon atoms per molecule and the spots? (*Some students will think there is and others won't notice yet.*)

Viscosity Test – The Air Bubble Race

In this part of the activity, students will determine the relative viscosities of a variety of fuels and feedstock oils. Use the dialogue below to introduce this lab. Before starting Lab B complete the following:

Ask students:

- What do you know about viscosity? (*Sample answers: How thick, gooey, or sticky a fluid is; how much a fluid resists flow; or how much internal friction a fluid has.*)
- Have you heard the expression "slow as molasses"? For example, "that runner is as slow as molasses!" Does molasses have high viscosity or low viscosity? (*It has a very high viscosity.*)
- What are other examples of a high viscosity fluid? (*Examples: honey or corn syrup*)
- What are examples of a low viscosity fluid? (*Examples: water or alcohol*)
- Sometimes the expression goes "slow as molasses in January". Why would molasses be different in January? (*Things move slower when cold; maybe it freezes.*)
- What factors affect viscosity? *(Answers will vary – accept answers such as: How concentrated a solution is, the temperature, the sizes and shapes of the molecules that make up the fluid, the attraction between the molecules in the fluid.*)
- Why might viscosity be an important property to consider when evaluating fuel sources? *(Answers will vary – accept answers, such as: because if it is too high, it might gum up fuel lines or it might not flow through fuel lines when it is very cold; if it is too low, it might vaporize too easily in hot weather; higher viscosity fuels have more energy.*)
- What could we measure to compare the viscosities of different fluids? (*Sample answers: How fast it flows or how easily something moves through it.*)

Teacher Notes for Student Procedure Lab B

(*These directions are for using glass pipettes, or straws, and air. If students will test viscosity using acetate sheets raised to an angle that allows flow, adjust the procedure as needed.*)

1. Arrange the students in groups of 2-4, perhaps the same groups that they were in for Part A.
2. Pass out a student page for materials and procedure to each group and give the students a few minutes to review.
3. Once you have addressed any safety precautions as well as any student questions, distribute one set of the prepared air bubble viscosity test tubes to each lab team, and tell them to leave the tubes lying down until after the safety note and procedure are reviewed and they have made predictions.

SAFETY ALERT: Remind students to be careful handling the liquid-filled glass pipettes. Ensure they are wearing goggles and gloves, and review with them the proper procedures in case of breakage. Also, instruct students to tell you immediately if any of the pipettes leak.

4. Ask students (have them use lab journals to record responses):
    - How can we use these pipettes to compare viscosities? (*By comparing the time it takes the air bubble to travel the length of the pipette, and/or by determining the speed at which the air bubble travels – s=d/t*)
    - Which of these fluids do you predict will have the highest viscosity? The lowest viscosity? (*Answers will vary*)
    - Predict what will be the rank order of the fluids based on viscosity? What is your reasoning? (*Answers will vary*)
5. Students will invert the fluid-filled pipettes to determine the time it takes (or the speed at which) the air bubble travels the length of the pipette. Ranking the viscosities can be challenging because some of the bubbles travel very quickly, and races between fluids with similar viscosities may end in a tie. Students may need to strategize to figure out methods for determining a reasonable rank order. Remind students to record their data, methods, and thinking in their journals.
6. Have each lab team share their results and discuss challenges and strategies as a class.
7. Once students have completed the lab, ask them the following questions to guide them through their analysis and conclusion for Lab B:
    - How did your predicted rankings compare with the results? Explain. (*Answers will vary*)
    - Is there any relationship between the results from this test and those from the fuel spotting test? (*Answers will vary*)
    - How does viscosity correlate with the number of carbons in the molecules of these substances? (*viscosity increases as the number of carbons in the molecule increases*)

    Remind students to record responses in their journals where the questions could serve as a formative assessment

    After students record their data as a class for the viscosity lab:

8. Decide which fuel is most viscous and least viscous as a class.
9. Identify any patterns from the data. (*Students will likely recognize that canola oil is denser than the biodiesel.*)
10. Consider why canola oil is more viscous than biodiesel. (*The canola oil is denser because it contains more carbon chains than the biodiesel.*)

Teacher Strategy: If the Projected Image: Making and Testing Biofuels: Chemistry of Fuels from Part II p. 13 is not posted in the classroom somewhere, project this image now to help students make the connection from molecular structure to properties of the substance.

One way to measure relative viscosity is to determine how fast fluids flow compared to each other. Another way to compare viscosities is to observe/measure how fast the same object moves within different fluids, such as steel ball or, in this case, an air bubble.

Teaching Extension: Discuss possible strategies that might be used to rank the viscosities, especially if timing the bubbles proves challenging. For example:

- Qualitatively compare two fluids at a time until they can determine the rank order. (For larger sets, this task requires some critical thinking.)
- Determine an estimated range of values for the whole set of fuels and then establish time classes for sorting and ranking fuels (e.g., "the air bubbles in these two fuels took $\geq$ 0.3s <0.4s"). This simple learning activity allows for different levels of specificity and outcomes, depending on the ages and levels of the students.
- Use acetate sheets and eye droppers to put the same number of drops of different substances on sheets held at the same angle and either measure time to the bottom or note which drop got there 1st, 2nd, 3rd.
- Students should record their methods and their data, and organize, analyze, and communicate their findings. Consider having students display their findings graphically as well.
- Have student teams record their results in a data table that is visible to the whole class. Sample format and answers are included below

Sample Viscosity Test Ranking Results:

Directions: Rank 1 – 6 with 6 being the most viscous (thickest)

Sample Name	*Team 1*	*Team 2*	*Team 3*	*Team 4*	*Team 5*
Biodiesel	3	2	4	3	5
Canola Oil	5	5	5	5	4
Ethanol	1	1	1	1	3
Kerosene	2	3	2	2	1
Motor Oil	6	6	6	6	6
Water	4	4	3	4	2

Making Sense Discussion and Wrap-up

After students have concluded their comparative tests, summarize through class discussion what students learned. Use the following dialogue and guiding questions to do so.

Two scientific principles addressed in this lesson are:

1. In a chemical reaction, new substances are formed with new properties.
2. The molecular structure of a substance determines its properties.

The students will arrive at the first principle with help from Part II Making Biodiesel and Part III Testing Biodiesel. In Part I, students participated in the “See, Think, Wonder” discussion while looking at the molecular structure of biodiesel and vegetable oil in the projected image. This provided them with the background knowledge of the chemical structure of these molecules. In Part III, students compared the physical properties of these fuels by the spot testing and the viscosity testing.

Students arrive at the second principle because they started with canola (or another vegetable) oil in Part II and made it into biodiesel through the chemical reaction that they completed. They will know that the biodiesel has new properties compared to canola oil due to the spotting and viscosity tests as well as comparison of properties they completed in Parts II and III. From lab data, observations, the GREET graph, and examination of molecular diagrams, students have lots of evidence that suggests the second scientific principle of this activity.

Ask the students:

Most of these questions have been throughout these activities. Asking them again is a formative assessment opportunity.

1. What physical properties did you observe in the spot testing or the viscosity test? (*Darkness of spots, size of spots, evaporation time, how quickly the bubble moved up the tube*)
2. What do these physical properties tell you about the fuel? (*Darker/larger spots and slower moving bubbles occur in a fuel that has more carbons.*)
3. What were we trying to find out and what did we learn?
4. How does biodiesel compare to other substances in terms of viscosity?
5. What are the advantages and disadvantages of biodiesel fuel vs. other fuels?
6. How do these investigations increase your understanding of production and properties of biodiesel?
7. Ask students to trace carbon from the air to a plant to a fuel that burns.
8. What surprised you?
9. How can you use this information to help you solve the problem?
10. What new questions do you have?

Be sure to monitor student responses and provide appropriate feedback if choosing to collect these questions as formative assessments.

Problem Challenge Wrap-up

After completing all lab work and comparing data, ask groups to propose a solution to the Midwest's fuel problem, being sure to use information from class research. The final product can be a poster, lab report, or other communication that includes a claim, evidence, and scientific reasoning.

Student Handout: Materials
Testing Biodiesel and Other Fuels – Spotting Tests

Per Class

- A drop or two of each sample fuel and water as directed.
- 1 or more small beakers (50 mL) or dropper bottles for each substance
- 1 or more droppers for each substance
- Parafilm® or other material to cover beakers of substances when not in use, unless using dropper bottles or bottles with lids
- Labels and permanent fine-tipped marker or china marker to label beakers or bottles
- Heavy-weight paper and broad-tipped marker to make tent-card signs with substance names
- At least one eye dropper for each sample
- 1 or more digital cameras
    - **Note:** It is best to use glass containers and droppers, since biodiesel erodes many plastics and makes them gummy.

Per student

- Goggles
- Gloves
- Lab apron
- Journal

Safety Note: Review appropriate lab attire. If a ventilation hood is available, the stations for the gasoline and kerosene samples will be there. Be sure that the activity is performed in a well-ventilated area. Cover the samples (with plastic wrap, cap or Parafilm®) after each use to reduce the amount of fuel vapor released.
DO NOT sniff the substances. Your teacher will demonstrate how to determine odor using the wafting technique. You must avoid breathing fuel vapors.

Per group

- Spotting paper
- Parchment (or waxed) paper to place under the spotting paper (cut to approximately same size as the spotting paper)
- Ruler for drawing a sampling matrix
- Pencil or fine-tipped, permanent marker

Student Handout: Procedure
Testing Biodiesel and Other Fuels - Spotting Tests

1. Draw lines or fold seams into the paper provided. Try to make approximately equal sized rectangles for each sample you are going to test.
   Note: The number of rectangles (or cells) in the matrix of your paper will depend on the number of samples tested.
2. Use a pencil or a fine-tipped permanent marker to write the names of the samples being tested in each cell on the paper matrix.
3. When you rotate to each sample station, use the dropper provided to place 3 drops, on top of each other, in the appropriately labeled cell.
   Note: Be sure to cover the samples after you have taken the 3 drops.
4. When all fuels have been spotted, place the spotting papers in a hood or well-ventilated area to dry.
5. At 5 and at 20 minutes, outline the spots with pencil and take a photo of each of the spotting papers.

Name_______________________________ Class___________ Date________

Part III: Testing Biodiesel and Other Fuels - Spotting Tests

Objectives:
Students will compare and contrast various properties of different fuel sources in order to learn more about the biodiesel produced in Part II.

Introduction:
In this lab you will be performing spot tests with various fuels in order to observe some of its properties. Use your observations to build your evidence that you will use in your Scientific Explanation based on Evidence

Exploring the Phenomenon: Laboratory Experience
Once you have completed your spot testing. Rank the top five substances with the darkest remaining spots.

- What might the relative darkness or spread of these spots tell you about these substances? What makes you say that?
- How many carbons does a molecule of each of these substances contain? Or, how does the carbon content of these five substances compare to the other substances?
- Which fuels come from petroleum and which come from plants?
- Observe the spot sheets, again, at 24, 48 and 72 hours. Record your observations in your journal. Does anything on the spot tests change over time?

Making Sense/Wrap up:
After completing the lab, answer the following questions:

1. How might the properties of these substances relate to the number of carbon atoms in the different fuel or oil molecules?
2. Is there a relationship between the number of carbon atoms in a molecule for each of these substances and the properties observed?
3. What might a spot that evaporated quickly mean about that substance? What makes you say that?
4. Do you notice any other patterns, categories, or generalizations based on the observations?

Student Handout: Materials
Testing Biodiesel and Other Fuels – Viscosity Tests

Per student

- Goggles
- Gloves
- Journal

Per Group

- 5–10 10 mL glass serological pipettes (1 per fluid) (or plastic straws, or glass vials with caps), labeled and filled with:
  - Fuel Samples provided
  - Oil Samples provided
  - Water (for reference)
- Stopwatch

Note: Your teacher may have already constructed kits of the pipettes. In this case you will only need one set of the pipettes that your teacher has prepared. Check with your teacher to make sure you have each pipette that you need.

Student Handout: Procedure
Testing Biodiesel and Other Fuels - Viscosity Tests

1. Obtain a set of air bubble viscosity pipettes*. Leave the pipettes lying down until after your teacher has reviewed the safety and procedure.
   *Or whatever materials you will be using for the viscosity testing.

SAFETY ALERT: Be careful handling the liquid-filled glass pipettes. You must wear goggles and gloves. Be sure to follow classroom procedures if any glassware breaks. If any pipettes begin to leak, inform your instructor immediately. If you are not using glass pipettes, you should still wear goggles and gloves while handling the fuels.

2. Answer the following questions in your journal:
   - *Predict:* How can we use these pipettes to compare viscosities?
   - *Predict:* Which of these fluids do you predict will have the highest viscosity? The lowest viscosity?
   - *Predict:* What will be the rank order of the fluids based on viscosity? What is your reasoning?
3. Invert the fluid-filled pipettes to determine the time it takes for the air bubble to travel the length of the pipette.
   Note: Ranking the viscosities can be challenging because some of the bubbles travel very quickly, and races between fluids with similar viscosities may end in a tie. You may need to strategize with your lab group to figure out methods for determining a reasonable rank order.
4. Create a table in your journal or fill out the sample data table below:

Sample	Test 1:(short description)	Test 2:(short description)	Test 3:(short description)

Name________________________________ Class___________ Date________

Testing Biodiesel and Other Fuels - Viscosity Tests

Objectives:

1. Compare and contrast various properties of different fuel sources to learn more about the biodiesel you produced in Part II.
2. Relate the viscosity of a substance to the number of carbons that the substance contains.

Introduction:

In this lab you will perform viscosity tests with various fuels in order to observe some of their properties. Use your observations to build your evidence that you will use in your solution to the Problem Challenge.

Analysis and Conclusion: Answer the following questions in your journal or here.

1. How did your predicted rankings compare with the results? Explain.

2. Is there any relationship between the results from this test and those from the fuel spotting test? Explain.

3. How does viscosity correlate with the number of carbons in the molecules of these substances?

4. Share your viscosity results and discuss challenges and strategies as class.
    a. Were there any common strategies across all the groups?

    b. Were there any strategies that only one group employed?

5. If you were to complete this experiment again, what strategy would you use? Explain.