# SOLUTIONS:
## Freezing Point Depression of Biodiesel

**Georgia Performance Standards:** SCSh1-9, SC7a
**National Science Standards:** Content Standards A, B: properties of substances

**Objective:** Students will test the freezing point of B100 and various blends with kerosene. Students will calculate the freezing point depression constant for biodiesel as a solvent.

**Essential Questions:**

1. How does a nonvolatile solute affect the freezing point of a solvent?
2. Why is it necessary to "winterize" biodiesel fuel?

**Background:** Most biodiesel will freeze at a temperature that is much higher than other petroleum based fuels will. For those people living in colder climates, this can present a problem with clogged fuel lines. In order to use biodiesel in the winter or in colder climates, it is necessary to "winterize" the fuel by putting in an additive. Some biodiesel retailers will even add a certain percentage of kerosene to the biodiesel in order to lower its freezing point. Kerosene has an average molar mass of 170 g/mol and a freezing point of -51°C.

A nonvolatile solute (one that does not evaporate easily) will lower the freezing point of a solvent. The solute particles will be between the solvent particles and will interrupt the intermolecular forces in between the solvent particles making it harder for them to "stick together" through attractions.

**Materials:**

1. Clean biodiesel (can be purchased)
2. Kerosene
3. five large test tubes
4. five 100 mL beakers
5. Vernier Logger Pro software and temperature probes
6. Ice
7. Buckets/Large beakers for ice
8. graduated cylinders

**Procedure:**

Before you begin, state your hypothesis. Think about whether the kerosene will lower the freezing point or not and if it will be a linear relationship with the blends.

1. Obtain five 100 mL beakers and five large test tubes.
2. You need to make 50 mL of five blends:
   0% kerosene/100% biodiesel
   0.5% kerosene/99.5% biodiesel
   1% kerosene/99% biodiesel
   2% kerosene/98% biodiesel
   5% kerosene/95% biodiesel
   Make sure you label your beakers. Show your calculations for this step.
3. Label the five test tubes and pour each blend into each test tube about ¾ full.
4. Put ice and a small amount of water in a bucket or beaker.
5. Put the cork/stopper into the test tube and insert the temperature probe into the hole. Make sure the temperature probe is also inside the solution in the test tube (add more solution if necessary)
6. On the Logger Pro software on the computer, go to 'experiment' at the top and click on 'data collection.'
7. Make sure it says Mode: 'Time Based' Length: '30 minutes' and '2 samples/minute'
8. Click 'Done'
9. Put the test tube into the ice and click the green "play" button at the top (for collect).
10. Let the sample cool and the computer take data. Stir the sample every minute. Take note of the temperature at which you first start to see waxy crystals form.
11. Repeat these steps for each blend. You can go to File, New to start a new collection.

**Assessment:** Lab rubric

**Questions:**

1. Calculate the molality of each of the blend solutions.
2. Using the equation, $\Delta T_f = k_f\, m$, calculate the freezing-point depression constant for biodiesel. Average your answer for all the blends.

3. Make a graph of freezing point vs. percent kerosene. You may either graph by hand on graph paper or you may use Microsoft Excel. Make sure you are NOT connecting the dots! Make a “best-fit” line.
4. Which is the best blend to use in the winter? Using the information from your previous calculations and graph, calculate the expected freezing point for a 50% blend of kerosene and biodiesel.

## **Lab Data Sheet - Solutions**

Hypothesis:

Calculations for the Blends:

| Blends | mL biodiesel needed | mL of kerosene needed |
|---|---|---|
| 0% kerosene/100% biodiesel | | |
| 0.5% kerosene/99.5% biodiesel | | |
| 1% kerosene/99% biodiesel | | |
| 2% kerosene/98% biodiesel | | |
| 5% kerosene/95% biodiesel | | |

(Show all calculations on a separate sheet)

Crystal Formation:

| Blends | Temp of crystal formation (°C) |
|---|---|
| 0% kerosene/100% biodiesel | |
| 0.5% kerosene/99.5% biodiesel | |
| 1% kerosene/99% biodiesel | |
| 2% kerosene/98% biodiesel | |
| 5% kerosene/95% biodiesel | |

Molality:

| Blends | Molality of solution | Calculated $K_f$ |
|---|---|---|
| 0% kerosene/100% biodiesel | | |
| 0.5% kerosene/99.5% biodiesel | | |
| 1% kerosene/99% biodiesel | | |
| 2% kerosene/98% biodiesel | | |
| 5% kerosene/95% biodiesel | | |

(Show all calculations on a separate sheet)

Graph freezing point vs. %kerosene using MS Excel or graph paper. Attach graph.

Calculate the freezing point expected for a 50% blend of kerosene and biodiesel.

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## Instructor Notes

If you do not have access to computer temperature probes and graphing software, you may have the students manually record the temperature every 30 seconds and then use Microsoft Excel to make a plot of time vs. temperature. The lab was written for use with the Vernier Lab Pro software and probes. These items can be purchased at http://www.vernier.com

This lab can be modified in several ways, do what works best in your lab with your students:

Biodiesels made from different feedstocks can be used. Biodiesel from canola and soy often have fairly good cold-weather properties. Biodiesel from feedstocks such as palm oil, peanut oil, and animal fats have worse cold-weather properties.

Different percentage blends can be used depending on how cold you can get the samples in your lab.

You can have the students calculate freezing points of other blends by extrapolating from the graph (and not using the equation).

Kerosene information:
http://www.osha.gove/dts/sltc/methods/partial/pv2139/pv2139.html

Cold- Weather Blending:
http://www.biodiesel.org/resources/reportsdatabase/reports/gen/20050728_Gen_354.pdf