

Research Conducted By: Amy Johnston, Olathe North High School & Jennifer Gartner, Labette County High School

Learning Experience Title:

“Make Biodiesel and ‘still’ use the Methanol”

Learning Experience Description:

To distill a solution that contains at least two solutions of different boiling points. To describe the intermolecular forces effects on the boiling points of the included solutions. We suggest using a teacher made mixture of methanol and water **or** glycerol a by-product of the biodiesel process.

Bioscience Connection:

Distillation is a refining process for the by-product of biodiesel production, glycerol. Methanol must be removed before glycerol can be used. The methanol is toxic and detrimental to the environment.

Background Information:

Boiling points of methanol 66°C, water 100°C, and glycerol 279°C must be known. www.youtube.com/watch?v=xxNfjLMNS4E, is a video that explains the basic principles of distillation. Distillation is a process of separating a liquid solution into its compounds using the boiling points of the various compounds to isolate each. The separated vapor is then condensed back into a liquid and collected for further use or analysis. Intermolecular forces present in covalent compounds affect the boiling point. The energy needed to completely overcome the intermolecular forces on the glycerol is greater than the energy needed for methanol and water simply because number of bonds present in the glycerol are much greater than in methanol and water.

Grade Level:

High School: Physical Science, Chemistry, Physics & Biology Extensions under Post-Visit Classroom Information

Duration of Learning Experience:

One-hour class period depends on the lab set-up of the still.

Pre-Visit Classroom Information:

Worksheet with boiling points of compounds of interest and basic theories of distillation. This worksheet is available in Lesson Materials Appendix A

Post-Visit Classroom Information:

On the next exam ask a questions like those listed in the Lesson Materials Appendix B

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EXTENSIONS: (optional)

Biology Extension: This lesson can further be extended by a Biology class if the wash water used to refine a batch of biodiesel were distilled (so that the toxic methanol is removed) and then several plants are treated with non-methanol wash water of different concentrations as well as tap water (as a control). Plant growth can then be graphed and conclusions drawn as to whether biodiesel wash water can be used as a fertilizer.

Physic Extension: Glycerol is being investigated by agriculture as a possible additive for crop dusting. The glycerol may add weight to the chemicals and make the spray patterns more accurate. The glycerol might also aid to the adhesion of the agricultural chemicals ability to adhere to the plants. Testing various %m comparisons of water and glycerol in small spray bottles (found in the beauty section of a department store) a small fan represents the wind velocity as well as the plane's velocity. A piece of butcher paper is placed on the floor and no glycerol, 10% glycerol etc. are tested and the spray patterns analyzed for the best results, a precision spray pattern.

Concept / Topic:

Boiling points

Phase change

Separation techniques, distillation

Intermolecular forces

Covalent bonds

Vocabulary:

Covalent bonding

Temperature ($^{\circ}\text{C}$)

Boiling points

Phase of matter

Molecular motion in various phases of matter

Homogeneous Solution

Intermolecular forces

Content Standards, Benchmarks, and Indicators Addressed:

STANDARD 1 - Science as Inquiry

STANDARD 2A: CHEMISTRY Grades 8-12

CHEMISTRY – The student will develop an understanding of the structure of

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**atoms, compounds, chemical reactions,
and the interactions of energy and matter.**

Benchmark 2: The students will understand the states and properties of matter.

The student ...

1. ▲ understands chemists use kinetic and potential energy to explain the physical and chemical properties of matter on earth that may exist in any of these three states: solids, liquids, and gases.

Technology Standards Addressed:

STANDARD 5: SCIENCE AND TECHNOLOGY Grades 8-12

SCIENCE AND TECHNOLOGY – The student will develop understandings about the relationship between science and technology.

Benchmark 1: The student will develop an understanding that technology is applied science.

The student ...

1. ▲ understands technology is the application of scientific knowledge for functional purposes.

Learning Experience Objectives:

To distill a solution that contains at least two solutions of different boiling points to draw conclusions about the number of carbon atoms and boiling point

To describe the intermolecular forces effects on the boiling points of the included solutions.

Required Materials:

2 Erlenmeyer flasks 250mL

thermometer Flinn Cat # AP8872 \$10.15/EA

OR Go Temp <http://www.vernier.com/go/gotemp.html>

6mm glass tubing Flinn Cat #GP9010 \$9.90/PKG OF 10 24" long

#6 stopper with 2 holes Flinn Cat #AP 2316 \$12.15/18 stopper

clear vinyl tubing hardware store 5/16 OD, 3/16 ID

hot plate

ice

Pyrex dish 1L or 4 cups or 800mL to 1L beaker cookware aisle Wal-Mart

molecular models

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Stock Solution (student's unknown) contains 25 mL of methanol and 50 mL of water for each distillation. OR if biodiesel has been made earlier in the year use the glycerol produced (the bottom layer) or wash waters as the unknown

Lab Safety:

Glass doesn't change colors when hot so beware of hot glass. Methanol is highly flammable so do not use a Bunsen burner to provide heat for your distillation set-up. The glassware has a tendency to tip so secure with clamps and ring stands as needed.

Technology Connection:

A digital thermometer such as the Vernier Go Temperature can be used for the distillation. If the software LoggerLite is used a graph of temperature versus time can be printed the boiling point of the various compounds labeled as well as the phase of matter.

If further and more in-depth explanations of index of refraction and its physics applications are needed a lecture from MIT is available at iTunes University "Lecture 28: Index of Refraction" in the Collection Electricity & Magnetism by Professor Walter Lewin

Anticipatory Set:

Teacher performs the demonstration of molecular models of each covalently bonded compound and shows how when placed in a box the smaller models bounce out of the box more easily than the bigger glycerol molecules. The interferences that can be made about intermolecular forces is discussed.

Step-By-Step Procedures:

Basic Procedure: To start the lesson the teacher will illustrate the various boiling points of alcohols and water. We suggest methanol, ethanol, propanol, and water. A hot plate should be placed on a demonstration table. A diagram of four quadrants with each labeled can be put on the board or displayed on an overhead. *Appendix C, a PowerPoint of the diagram is provided.* Place a few milliliters of each in the appropriate quadrant. Turn on the hot plate, have students record the order that each evaporates (boiling points). Have students look at their worksheet. *Appendix A.* Do their observations confirm the boiling point data they have gathered? It should. Review the dangers of the flammable alcohols about to be distilled.

Place the unknown (or biodiesel glycerol) a homogeneous solution in an Erlenmeyer flask.

Using a #6 stopper with 2 holes, insert a thermometer in one hole and a 3-inch piece of 6mm glass tubing in the other.

Connect a 3 feet piece of 5/16 outer diameter clean vinyl tubing to the glass tubing.

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Position the second Erlenmeyer flask that should sit in an ice bath, at the other end of the tubing so that the solution when distilled will drip into the second flask.

Position ring stands as needed so that the apparatus will not tip over.

Turn on the hot plate and record the temperature at which the solution boiling. If a second boiling point to observed record it as well.

Using your recorded boiling point what do you think was in the solution?

Provide data to support your conclusion.

Plot a graph of boiling points vs. the number of carbons. Label each phase of matter and describe the molecule's motion in that portion of the graph.

Using your graph, what do you predict the boiling point of a C₅ alcohol would be?

An exam containing questions that access the level of comprehension is attached in Appendix B

Lesson Materials to Be Attached:

Appendix A: Worksheet on Boiling Points data and Distillation basic theory

Appendix B: Exam questions

Appendix C: Diagram of 4 quadrants for the opening activity

Appendix D: Next day starter question

www.youtube.com/watch?v=xxNfjLMNS4E, video explaining basic distillation principles

Assessment:

The use of their predictions on the C₅ boiling point is a formative assessment. A starter question given in Appendix D also provides a formative assessment. A summative assessment can be found in Appendix B. All levels of Bloom's Taxonomy are presented in the exam.

Closure (Reflect Anticipatory Set):

You are given a bottle of unknown liquid. How could you use what you have learned to identify the liquid? Using your data and information from you book, make up the identity of the chemical and provide fake data to support your findings.

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hot plate

ice

Pyrex dish 1L or 4 cups cookware aisle Wal-Mart

methanol

ethanol

propanol

water

(glycerol recovered from the biodiesel)

molecular models