WMRC

Greening Schools's Green Chemistry Lessons

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Biodiesel—Using Renewable Resources

Objectives

1) Examine ways to use renewable resources to replace nonrenewable starting materials.
2) Examine characteristic properties of matter

Green Chemistry Principles

1) Safety first-and last.
2) Wastes? Why make them?
3) Use renewable resources

IL State Standards (Science)

11.A.3a, 11.A.3b, 11.A.3f, 11.A.4a, 11.A.4b, 11.A.4c, 11.A.4d, 11.A.4f, 11.A.5a, 11.A.5d, 12.B.3a, 12.B.4a, 12.C.5a, 12.E.3c, 13.B.3e, 13.B.3f, 13.B.4c, 13.B.5d, 13.B.5e

Levels

High school (may be used as a demo for discussion in middle school classes)

Vocabulary

Combustion, synthesis, catalyst

Materials

- lab balance
- 1 250-mL Erlenmeyer flask
- 2 100-mL beakers
- 1 25-mL graduated cylinder
- 1 100-mL graduated cylinder
- 5 Beral pipettes
- distilled water
- 100 mL canola or other vegetable oil
- 15 mL methanol *Cautionary note: Flammable, dangerous fire risk, toxic by ingestion*
- 1 g 9 M potassium hydroxide (KOH) solution

Cautionary note: Skin contact causes severe blisters, strongly corrosive, very harmful if swallowed, extremely dangerous to eyes, generates large amounts of heat when solution is prepared. Consider immersing solution container in ice bath when preparing.

Time

One class period.

This material is adapted from the ACS text *Introduction to Green Chemistry*. See the "references" section of the introduction to this manual for additional information on this text.

Background/Overview

One of the ways in which processes can be made "greener" is to use renewable resources to replace nonrenewable starting materials. This is one of the basic principles of green chemistry. Using starting materials such as substances derived from growing plants, rather than irreplaceable materials like the Earth's petroleum and natural gas is one way in which we seek use renewable resources. This activity will allow the students to make fuel from vegetable oil as a demonstration of the green chemistry principle of using renewable resources. It will also demonstrate the green chemistry principle, Waste? Why Make Them?

To illustrate visually the generation of waste and product, we will use bio-diesel. Biodiesel is a mixture of methyl esters of fatty acids. It can be made very easily from vegetable cooking oil. Enough fuel can be produced from this lab to burn in a later activity, although it is not pure enough to actually be used as fuel in a car or truck. The synthesis is a simple chemical reaction that produces biodiesel and glycerol. Cooking oil is mixed with methanol, while potassium hydroxide is added as a catalyst. The products separate into two layers, with the biodiesel (desired product) on the top. The biodiesel is separated and washed and is then ready for further experimentation.

Safety

- ***You must wear goggles and an apron.***
- ***Methanol is flammable and poisonous. Dispose of excess by allowing it to evaporate in a fume hood.***
- ***Potassium hydroxide is corrosive. Dispose of excess potassium hydroxide by neutralizing with 3 M hydrochloric acid and put neutral solution down the drain with lots of water.***

Procedure

1. Measure 100 mL of vegetable oil.
2. Carefully add 15 mL of methanol.
3. Slowly add 1 mL of 9 M KOH.
4. Stir or swirl the mixture for 10 minutes.
5. Allow the mixture to sit and separate.
6. Carefully remove the top layer using a Beral pipette.
7. Wash the product using 10 mL of distilled water. Mix.
8. Allow the mixture to sit and separate.
9. Carefully remove the top layer using a Beral pipette.
10. Measure the amount of biodiesel you have collected and compare it to the amount of vegetable oil you started with.

\Discussion Questions

1) What changes did you see between the characteristics of the starting materials (cooking oil, methanol, and potassium hydroxide solution) and the final products (biodiesel and glycerol)?
2) Which did you have more at the end, the product or the waste?
3) What signs did you observe that a chemical reaction had taken place?
4) What is the purpose of the washing step 7 above?
5) In the commercial production of biodiesel, 1200 kg of vegetable oil produces 1100 kg of crude biodiesel. How does your yield compare to this?

Instructional notes " Making biodiesel"

In this activity, students make biodiesel from cooking oil. The cooking oil is mixed with methanol and a catalyst (potassium hydroxide). Cooking oil is a lipid called a triglyceride or triacyglycerol. The structure of this type of lipid is characteristic of all animal and plant fats. It consists of a glycerol attached to three fatty acids. Differences among the fats are due to the different fatty acids connected to the glycerol.

In making biodiesel, the reaction breaks the bond between the glycerol and the fatty acids. A methyl group is added to the end of the fatty acid, which is what we call biodiesel, and the other products are glycerol and the remaining potassium hydroxide catalyst.

References

1. The Office of Fuels Development for the U.S. Department of Energy has several pages related to biodiesel and other plant-derived fuels at www.ott.doe.gov/biofuels.
2. The National Biodiesel Board, www.biodiesel.org.
3. A comprehensive report on the economics and science of using soybeans to make biodiesel is presented at www.mda.state.mn.us/ams/ soydieselreport.pdf.

For additional information on Green Chemistry and Greening Schools lessons from Illinois Waste Management and Research Center, visit www.greeningschools.org, or call 217-244-5637.