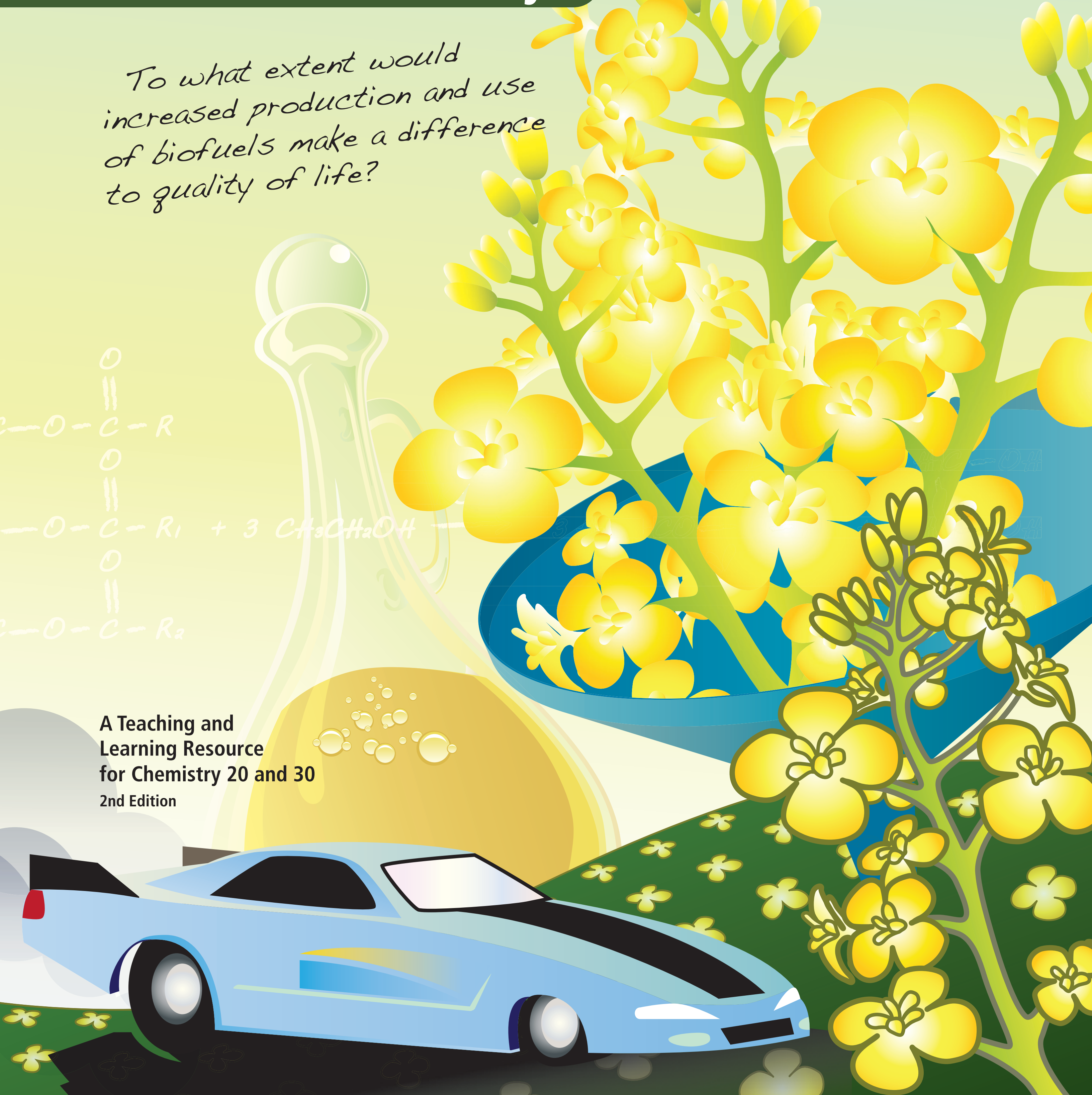
Alberta Canola Producers Commission

Critical Issues Guides

Agriculture in Education:
Exploring Critical Issues

Biofuels
Choice or Necessity?

To what extent would increased production and use of biofuels make a difference to quality of life?



A Teaching and Learning Resource for Chemistry 20 and 30

2nd Edition

Biofuels: Choice or Necessity?

2nd Edition

The machines that power the Canadian economy – heavy equipment, long-haul trucks, farm machinery, municipal fleets, generators – are powered by diesel fuel. In almost every instance, biodiesel is the best fuel alternative that will help clean the air that we breathe and reduce greenhouse gas emissions.

Canola biodiesel is:

- *Good for the environment – Biodiesel production and use reduces greenhouse gas emissions by more than 85% compared to petroleum diesel. That means the trucks and heavy machinery that drive the Canadian economy can burn cleaner fuel – today.*
- *Made in Canada – A made-in-Canada biodiesel industry will keep fuel production, resources and jobs in our country.*
- *Good for the Canadian economy and farmers – The biodiesel industry will further diversify the Canadian farm economy and create opportunity for industry investment.*

Why canola biodiesel?

- *Canola's unique characteristics make it an ideal feedstock for biodiesel.*
- *Canola's high oil content means more oil available per unit of seed.*
- *Canola is low in saturated fat, a characteristic that improves cold weather performance for biodiesel.*
- *Canola biodiesel is a proven fuel commonly used in Europe.*

For canola farmers, this decision does not start a debate on food versus non-food uses. Being able to produce biodiesel within a classroom provides students with an understanding of science in a daily application. By adding a critical issues component – such as the choice of which feedstock should be used to make the biodiesel or the implications of a nationally mandated inclusion of biodiesel to petroleum-based diesel fuels – current social discussions become relevant to today's students.

As in all the resources developed by the Alberta Canola Producers Commission, the websites in these lessons were current as of the printing date of this publication. It is, however, beneficial to preview all websites before asking students to use them. As well, every effort has been made to acknowledge sources used. Should any question arise from the use of this material, we will be pleased to make the necessary corrections in future printings.

Simone Demers Collins, BSc PHEc
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Alberta Canola Producers Commission (ACPC)

Alberta Canola Producers Commission gratefully acknowledges the following groups and individuals who have participated in the development of this resource.

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Every effort has been made to acknowledge sources used in this resource. If any have been inadvertently missed, please contact Patricia Shields-Ramsay at InPraxis Group Inc. at 866.925.7163. Corrections will be made in subsequent printings.

CONTENTS

BIOFUELS: CHOICE OR NECESSITY?

To what extent would increased production and use of biofuels make a difference to quality of life?

INTRODUCTION & OVERVIEW

Biofuels are alternative fuel sources that are produced from renewable sources such as those found in vegetable oils like canola, soy or palm, animal fats, wheat or other grains and grasses, as well as low grade recycled cooking oils and trap grease that go through a chemical manufacturing process. Biodiesel is a biofuel that can be combined with petroleum diesel as an energy source for diesel engines. Biodiesel has also been made from stinkweed seeds that are removed in the grain cleaning process, from algae and from many other products that have fatty acids in their make-up. Biofuels are described as clean burning, non-toxic and biodegradable. With such obvious benefits associated with this alternative energy source, why is its use sometimes considered to be controversial? This resource explores the chemistry of biodiesel production and its economic, social and environmental implications. Students consider to what extent biodiesel can be considered a “better” choice and assess the extent to which it should, or should not, replace fossil fuel production.

A Critical Issues Approach

Issues that are relevant and meaningful to students support a constructivist, inquiry-based approach to learning. Critical issues frame learning around key questions that pose problems that intrigue and interest students, and set a focus for motivated learning. Posed effectively, critical issues ask students to develop and apply critical thinking skills and look at multiple perspectives, consider alternatives, and recognize that challenges can often involve many different solutions.

This teaching and learning resource is developed around a critical issues approach and promotes inquiry-based learning and critical thinking. The exploration of issues is framed around inquiry questions that are relevant and meaningful to students, engage them in deliberative research and promote social participation skills.

Curriculum Support

This resource supports Alberta’s **Chemistry 20 and 30** program of studies as well as the **Information, Communications and Technology (ICT)** program. The resource addresses concepts related to biotechnology and biofuels and supports **Chemistry 20** concepts in **Unit A: The Diversity of Matter and Chemical Bonding, Unit C: Matter as Solutions, Acids and Bases** and **Unit D: Quantitative Relationships in Chemical Changes.** It supports **Chemistry 30** concepts in **Unit A: Thermochemical Changes** and **Unit C: Chemical Changes of Organic Compounds.** This resource also develops processes and skills, including critical and creative thinking, decision making and problem solving, research and information inquiry, oral, written and visual literacy. A curriculum correlation chart follows. Specific charts are provided with each of two lesson sequences in this resource, indicating curriculum outcomes for each lesson sequence. These lesson sequences include activities that may take **three to five 80-minute class periods, depending on activities selected**.

Activities specific to Chemistry 30 learning outcomes are indicated with this icon.

Biofuels: Choice or Necessity?
Alberta Chemistry 20 Curriculum Connections Summary

Critical Issue & Inquiries

To what extent would increased production and use of biofuels make a difference to quality of life?

Analyze This

How do the properties of biodiesel make it an alternative fuel source? (Lesson Sequence One)

Pro or Con?

To what extent should biodiesel replace or support current production of traditional diesel fuels? (Lesson Sequence Two)

***Attitude Outcomes**

that support the responsible acquisition and application of knowledge related to science and technology are also developed and supported by this resource.

Knowledge Outcomes

- **20–A2.1k** recall principles for assigning names to molecular substances
- **20–A2.2k** explain why formulas for molecular substances refer to the number of atoms of each constituent element
- **20–A2.6k** illustrate, by drawing or by building models, the structure of simple molecular substances
- **20–C1.11k** describe the procedures and calculations required for preparing and diluting solutions.
- **20–D2.2k** identify limiting and excess reagents in chemical reactions
- **20–D2.6k** describe the function and choice of indicators in titrations

Skill Outcomes

- **20–A2.1s (1)** state a hypothesis and make a prediction about the properties of molecular substances based on attractive forces; *e.g., melting or boiling point, enthalpies of fusion and vaporization*
- **20–A2.2s (2)** carry out an investigation to determine the melting or boiling point of a molecular substance
- **20–A2.3s** analyze data and apply mathematical and conceptual models to develop and assess possible solutions
- **20–A2.4s** work collaboratively in addressing problems and apply the skills and conventions of science in communicating information and ideas and in assessing results

  *analyze and evaluate, objectively, models and graphs constructed by others

  *research the ways that scientists develop and analyze new materials
- **20–C2.3s (1)** use experimental data to determine the concentration of a solution
- **20–D2.2s (1)** perform a titration to determine the concentration of an acid or a base restricted to strong monoprotic acid–strong monoprotic base combinations

Science, Technology & Society Outcomes

- **20–A2.1sts** explain that the goal of science is knowledge about the natural world
- **20–A2.2sts** explain that scientific knowledge and theories develop through hypotheses, the collection of evidence, investigation and the ability to provide explanations
- **20–A2.3sts** explain that scientific knowledge is subject to change as new evidence becomes apparent and as laws and theories are tested and subsequently revised, reinforced or rejected
- **20–D1.1sts** explain that the products of technology are devices, systems and processes that meet given needs; however, these products cannot solve all problems

ICT Outcomes

C.1 Students will access, use and communicate information from a variety of technologies.

- **ICT–C1 4.1** plan and perform complex searches, using more than one electronic source
- **ICT–C1 4.2** select information from appropriate sources, including primary and secondary sources
- **ICT–C1 4.3** evaluate and explain the advantages and disadvantages of various search strategies
- **ICT–C1 4.4** communicate in a persuasive and engaging manner, through appropriate forms, such as speeches, letters, reports and multimedia presentations, applying information technologies for context, audience and purpose that extend and communicate understanding of complex issues

C.2 Students will seek alternative viewpoints, using information technologies.

- **ICT–C2 4.1** consult a wide variety of sources that reflect varied viewpoints on particular topics
- **ICT–C2 4.2** evaluate the validity of gathered viewpoints against other sources

C.3 Students will critically assess information accessed through the use of a variety of technologies.

- **ICT–C3 4.1** assess the authority, reliability and validity of electronically accessed information
- **ICT–C3 4.2** demonstrate discriminatory selection of electronically accessed information that is relevant to a particular topic

C.6 Students will use technology to investigate and/or solve problems.

- **ICT–C6 4.5** evaluate the appropriateness of the technology used to investigate or solve a problem

Biofuels: Choice or Necessity?
Alberta Chemistry 30 Curriculum Connections Summary

Critical Issue & Inquiries

To what extent would increased production and use of biofuels make a difference to quality of life?

Analyze This

How do the properties of biodiesel make it an alternative fuel source? (Lesson Sequence One)

Pro or Con?

To what extent should biodiesel replace or support current production of traditional diesel fuels? (Lesson Sequence Two)

***Attitude Outcomes**

that support the responsible acquisition and application of knowledge related to science and technology are also developed and supported by this resource.

Knowledge Outcomes

- **30–A2.2k** explain the energy changes that occur during chemical reactions, referring to bonds breaking and forming and changes in potential and kinetic energy
- **30–A2.3k** analyze and label energy diagrams of a chemical reaction, including reactants, products, enthalpy change and activation energy
- **30–A2.4k** explain that catalysts increase reaction rates by providing alternate pathways for changes, without affecting the net amount of energy involved; e.g., enzymes in living systems.
- **30–C1.4k** identify types of compounds from the hydroxyl, carboxyl, ester linkage and halogen functional groups, given the structural formula
- **30–C1.7k** describe, in general terms, the physical, chemical and technological processes (fractional distillation and solvent extraction) used to separate organic compounds from natural mixtures or solutions; e.g., petroleum refining, bitumen recovery.
- **30–C2.1k** define, illustrate and provide examples of simple addition, substitution, elimination, esterification and combustion reactions
- **30–C2.2k** predict products and write and interpret balanced equations for the above reactions
- **30–C2.4k** relate the reactions described above to major reactions that produce thermal energy and economically important compounds from fossil fuels.

Skill Outcomes

- **30–A2.1s; 30–C1.1s; 30–C2.1s** formulate questions about observed relationships and plan investigations of questions, ideas, problems and issues

  *design an experimental procedure to illustrate the effect of a catalyst on a chemical reaction **(IP–ST2).**

  *design a procedure to identify types of organic compounds **(IP–NS1, IP–NS2, IP–NS3)**

  *design a procedure to separate a mixture of organic compounds, based on boiling point differences **(IP–ST2, IP–ST3).**

  *predict the ester formed from an alcohol and an organic acid **(IP–NS3)**

- **30–A2.2s; 30–C1.2s; 30–C2.2s** conduct investigations into relationships among observable variables and use a broad range of tools and techniques to gather and record data and information

  *perform an experiment to investigate the reactions of organic compounds; e.g.,

  – produce an ester
  – investigate methods of making soap **(IP–NS1, IP–NS2, IP–NS3, IP–NS4)**

  *use library and electronic research tools to collect information on:

  – the costs and benefits of supporting the petrochemical industry **(PR–SEC1, PR–SEC2) [ICT C1–4.1].**

- **30–A2.3s; 30–C2.3s** analyze data and apply mathematical and conceptual models to develop and assess possible solutions

  *use IUPAC conventions when writing organic chemical reactions **(AI–NS1)**

  *analyze efficiencies and negative by-products related to chemical processes in organic chemistry **(AI–ST2) [ICT F3–4.1].**

Science, Technology & Society Outcomes

- **30–A2.1sts** explain that the goal of technology is to provide solutions to practical problems **(ST1) [ICT F2–4.4]**
- **30–A2.2sts** explain that the appropriateness, risks and benefits of technologies need to be assessed for each potential application from a variety of perspectives, including sustainability **(ST7) [ICT F2–4.2, F3–4.1]**

  *assess, qualitatively, the risks and benefits of relying on fossil fuels as energy sources
- **30–A2.3sts** explain that the products of technology are devices, systems and processes that meet given needs; however, these products cannot solve all problems **(ST6) [ICT F3–4.1]**

  *evaluate the economic and environmental impacts of different fuels by relating carbon dioxide emissions and the heat content of a fuel
- **30–C1.1sts; 30–C2.1sts** explain how science and technology are developed to meet societal needs and expand human capability **(SEC1) [ICT F2–4.4, F2–4.8]**

  *describe where organic compounds are used in processes and common products, such as in hydrogenation to produce margarine and esters used as flavouring agents
- **30–C2.2sts** explain that science and technology have influenced, and been influenced by, historical development and societal needs **(SEC2) [ICT F2–4.8]**

  * describe processes involved in producing fuels
- **30–C2.3sts** explain how science and technology have both intended and unintended consequences for humans and the environment **(SEC3) [ICT F3–4.1]**

  *assess the positive and negative effects of various reactions involving organic compounds, relating these processes to quality of life and potential health and environmental issues; e.g.,

  – burning fossil fuels and climate change

  – by-products (CO_2, dioxins) of common reactions

  – transfats in the diet

Skill Outcomes

- **30–A2.4s; 30–C1.4s; 30–C2.4s** work collaboratively in addressing problems and apply the skills and conventions of science in communicating information and ideas and in assessing results

  *use appropriate SI notation, fundamental and derived units and significant digits to calculate and communicate enthalpy changes **(CT–ST2)**

  *use advanced menu features within word processing software to accomplish a task and to insert tables, graphs, text and graphics **(CT–SEC2) [ICT P4–4.3].**

ICT Outcomes

C.1 Students will access, use and communicate information from a variety of technologies.

- **ICT–C1 4.1** plan and perform complex searches, using more than one electronic source
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C.6 Students will use technology to investigate and/or solve problems.

- **ICT–C6 4.5** evaluate the appropriateness of the technology used to investigate or solve a problem

THE CRITICAL ISSUE & INQUIRY PROCESS

To what extent would increased production and use of biofuels make a difference to quality of life?

This Critical Issues Guide is one in a series of Critical Issues Guides produced by the ***Alberta Canola Producers.*** *Other Critical Issues Guides can be ordered or accessed on the Canola Learning Centre website at www.learncanola.com/learning_resources.aspx.*

Inquiries

How do the properties of biodiesel make it an alternative fuel source? (Lesson Sequence One)

In Lesson Sequence One, students focus on the production of biodiesel and associated chemical processes and properties. Students learn from, and experiment with, the properties of canola oil to expand their understanding of titration. They consider the implications of canola's flash point and molecular composition compared to other fuel choices.

To what extent should biodiesel replace or support current production of traditional diesel fuels? (Lesson Sequence Two)

In Lesson Sequence Two, students investigate perspectives involved in the economic, health related and environmental implications of biodiesel production and use. They focus on the challenges and benefits for quality of life that result from the use of biodiesel fuels and the questions and controversies that are associated with it. Students are also encouraged to explore current policies, including those of the federal government, and consider where they stand on the issue of increased biofuel production and use.

In their inquiry into this critical issue, students explore the chemistry and implications of increased production and use of biofuels as an alternative energy source. Students analyze the impact of biofuel production and use on society and the environment to assess its overall potential to affect quality of life. Students examine the reasons for and implications of biofuel production methods. They also consider how these decisions are interrelated with other factors – ongoing scientific research, consumer values, environmental movements, economic implications, ethics and social factors as well as farmers' opportunity to diversify their income. Students apply this exploration to building an understanding and making a personal decision about the future of biofuel use.

The Process

This resource is structured around two inquiry questions that form the basis for exploring the critical issue. Each inquiry question provides a focus for the lesson sequence and for deliberative research. Each lesson sequence also contains "I can…" statements that set a context for researching the essential learnings of the lesson sequence, provide criteria for assessment and help students focus their learning. These statements can be shared with students at the beginning of each lesson sequence.

Each of the lesson sequences in this resource is structured around the following features:

- Each lesson sequence provides activities that introduce and explore topics in **three to five 80-minute class periods.** Choices can be made by both the teacher and students about the scope and extent of research and assignments associated with the lesson sequence. Depending on the time available, modify the number of class periods for the lesson sequence.
- Additional activity suggestions provide opportunities to extend the lesson sequence and further develop research and inquiry skills.
- An overview of instructional strategies is provided with each activity.
- Rubrics can be used to assess many of the products that students create in the lesson sequences. Sample rubrics and criteria statements are provided at the end of this section of the resource, as well as a template for creating customized rubrics.
- Student products may be displayed and shared with other classrooms and students, the school, parents and the community. If appropriate, discuss ways that projects may be completed in cross-curricular contexts with other subject area teachers.

Each lesson sequence is self-contained and provides the instructional process, activity ideas, Briefing Notes and other handouts. **Therefore, teachers should select those activities in the lesson sequences that they believe will be most effective in supporting their students' learning in the Chemistry 20 or Chemistry 30 program.**

Briefing Notes

Each of the lesson sequences centres on a topic introduced through Briefing Notes. Each Briefing Notes handout opens with *Predict* questions that emphasize critical thinking and connect to students' prior knowledge, understandings, attitudes and assumptions.

The Briefing Notes also provide questions, activities and internet website links that encourage research and the exploration of multiple viewpoints and opinions on issues relating to agriculture, chemistry, biofuel production and technology.

The Briefing Notes format provides an opportunity for students to take on a variety of research roles. Each lesson sequence contributes to research that students gather to explore the critical issue. Students should be encouraged revisit, discuss and reflect on the critical issue when the lesson sequences have been completed.

At a Glance

The following chart provides an overview of each lesson sequence, inquiry focus, instructional strategies, curriculum connections and assessment focus in this resource.

__Chemistry 20__ and __30__ and __ICT__ outcomes are listed in full on pages 2 to 5.

Lesson Sequence One

Analyze This

In Lesson Sequence One, students focus on the production of biodiesel and associated chemical processes and properties. Students learn from, and experiment with, the properties of canola oil to expand their understanding of titration. They consider the implications of canola's flash point and molecular composition compared to other feedstock choices.

Inquiry Focus & Key Concepts

How do the properties of biodiesel make it an alternative fuel choice?

- Biofuels
- Biodiesel
- Cloud point
- Melting point
- Indicator
- Base
- Titration
- Catalyst
- Combustion
- Iodine value
- Viscosity
- Triglyceride
- Esters
- Methanol
- Glycerine
- Transesterification
- Reaction

Instructional Strategies

- Board Share Brainstorming
- Comparative Analysis and Lab Work
- KWHL Chart
- Flow Chart

Curriculum Connections Chemistry 20

Knowledge

- **20–A2.1k**
- **20–A2.2k**
- **20–A2.6k**
- **20–C1.11k**
- **20–D2.2k**
- **20–D2.6k**

STS

- **20–A2.1sts**
- **20–A2.2sts**
- **20–A2.3sts**
- **20–D1.1sts**

Skills

- **20–A2.1s (1)**
- **20–A2.2s (2)**
- **20–A2.3s**
- **20–C2.3s (1)**
- **20–D2.2s (1)**

Curriculum Connections Chemistry 20

Knowledge

- **30–A2.2k**
- **30–A2.3k**
- **30–A2.4k**
- **30–C1.4k**
- **30–C1.7k**
- **30–C2.1k**
- **30–C2.2k**

STS

- **30–A2.1sts (ST1) [ICT F2–4.4]**
- **30–C1.1sts; 30–C2.1sts (SEC1) [ICT F2–4.4, F2–4.8]**
- **30–C2.2sts (SEC2) [ICT F2–4.8]**
- **30–C2.3sts (SEC3) [ICT F3–4.1]**

Skills

- **30–A2.1s; 30–C1.1s; 30–C2.1s (IP–ST2)**
  ***IP–NS1, IP–NS2, IP–NS3**
  ***IP–ST2, IP–ST3**
  ***IP–NS3**
- **30–A2.2s; 30–C1.2s; 30–C2.2s**
  ***IP–NS1, IP–NS2, IP–NS3, IP–NS4**
- **30–A2.3s; 30–C2.3s**
  ***AI–NS1**
  ***AI–ST2 [ICT F3–4.1]**

Assessment Focus (I Can… Statements)

- **I can** analyze the meaning and implications of biofuel production on energy consumption and production.
- **I can** identify and describe processes used to produce biodiesel.

Students should understand the chemical processes associated with biodiesel production. They should also start to identify some of the chemical properties of biodiesel and consider issues and decisions associated with its use.

C.1 Students will access, use and communicate information from a variety of technologies.

- **ICT–C1 4.1**
- **ICT–C1 4.2**
- **ICT–C1 4.3**
- **ICT–C1 4.4**

C.2 Students will seek alternative viewpoints, using information technologies.

- **ICT–C2 4.1**
- **ICT–C2 4.2**

C.3 Students will critically assess information accessed through the use of a variety of technologies.

- **ICT–C3 4.1**
- **ICT–C3 4.2**

Pro or Con?

In Lesson Sequence Two, students investigate pros and cons related to the use of alternative energy sources, with a focus on biofuels. They identify benefits and drawbacks from different perspectives – scientific research, public opinion and government policy – as well as the potential impact of increased use of biofuels for quality of life and the environment.

Inquiry Focus & Key Concepts

To what extent should biodiesel replace or support current production of traditional energy sources?

- Alternative energy sources
- Renewable
- Fossil fuels
- Biodiesel blends
- Byproducts
- Flash point
- Fuel cells

Instructional Strategies

- Perspectives Poster Carousel
- Pros and Cons
- Concept Map
- Futures Wheel

Curriculum Connections Chemistry 20

STS

- **20–A2.1sts**
- **20–A2.2sts**
- **20–A2.3sts**
- **20–D1.1sts**

Skills

- **20–A2.4s**

Curriculum Connections Chemistry 30

Knowledge

- **30–C2.4k**

STS

- **30–A2.1sts (ST1) [ICT F2–4.4]**
- **30–A2.2sts (ST7) [ICT F2–4.2, F3–4.1]**
- **30–A2.3sts (ST6) [ICT F3–4.1]**
- **30–C1.1sts (SEC1) [ICT F2–4.4, F2–4.8]**
- **30–C2.3sts (SEC3) [ICT F3–4.1]**

Skills

- **30–A2.2s; 30–C1.2s; 30–C2.2s *PR–SEC1, PR–SEC2 [ICT C1–4.1]**
- **30–A2.4s; 30–C1.4s; 30–C2.4s *CT–SEC2 [ICT P4–4.3]**

Assessment Focus (I Can… Statements)

- **I can** assess different and conflicting perspectives and opinions on issues involving biofuel production and consumption.
- **I can** identify and interpret pros and cons related to biodiesel production and consumption.
- **I can** apply understandings of chemical properties and processes in order to analyze and evaluate information on the future of biofuels.

Students should understand background, research and opinions that underlie decisions about the use of biofuels and their application to the issue of environmental and economic sustainability.

ICT

C.1 Students will access, use and communicate information from a variety of technologies.

- **ICT–C1 4.1**
- **ICT–C1 4.2**
- **ICT–C1 4.3**
- **ICT–C1 4.4**

C.2 Students will seek alternative viewpoints, using information technologies.

- **ICT–C2 4.1**
- **ICT–C2 4.2**

C.3 Students will critically assess information accessed through the use of a variety of technologies.

- **ICT–C3 4.1**
- **ICT–C3 4.2**

C.6 Students will use technology to investigate and/or solve problems.

- **ICT–C6 4.5**

ASSESSMENT TOOLS

The assessment criteria statements that follow can be developed into rubrics and applied to many of the products that students develop in the activities in this resource. The criteria statements should be discussed, adapted and developed with students. A template is provided for the creation of customized rubrics.

VISUAL ORGANIZERS

Excellent 4	• Demonstrates a thorough understanding of the topic, its relationships and related concepts and ideas • Provides descriptive labels and organizers; provides information that reflects the topic • Makes appropriate links • Uses the visual organizer to make connections and draw relationships
Proficient 3	• Demonstrates an adequate understanding of the topic and concepts • Provides appropriate labels and organizers • Provides information that relates to the topic • Attempts to make links • Uses the visual organizer appropriately for topic and concepts
Acceptable 2	• Identifies concepts and ideas that relate to the topic • Provides labels and organizers • Includes information that relates to the topic • Uses the format of the visual organizer
Limited 1	• Provides limited information related to the topic • Uses parts of the visual organizer to present information

GROUP ACTIVITIES

Excellent 4	• Demonstrates clear understanding of the group task and their individual contribution to the group • Listens to group members • Expresses original opinions and ideas • Contributes meaningful information and research • Works with the group to fulfill group responsibilities
Proficient 3	• Articulates understanding of the group task and the role they play within the group • Listens to group members • Contributes ideas and information • Fulfills individual responsibilities for the group
Acceptable 2	• Describes the group task • Describes individual role within the group setting • Listens to group members • Contributes information to group task
Limited 1	• Describes individual role within the group setting • Listens to others in the group • Contributes limited ideas

RESEARCH

Excellent 4	• Develops a strategy for conducting research • Develops and identifies research and inquiry questions • Analyzes and assesses sources of information selected for the research task • Records information using an appropriate format • Applies research to inquiry question • Makes effective use of research time
Proficient 3	• Identifies a strategy for conducting research • Identifies research and inquiry questions • Selects and assesses sources of information • Records information using an appropriate format • Identifies links between research collected and inquiry question • Makes effective use of research time
Acceptable 2	• Uses a previously identified strategy for conducting research • Records research and inquiry questions • Selects and reads sources of information • Records information using an appropriate format • Uses information from sources to answer inquiry questions
Limited 1	• Selects and reads sources of information • Records identified research and inquiry questions • Records information using an identified format • Identifies information from sources that relates to inquiry questions

PROJECTS

Excellent 4	• Develops a project planning strategy and process • Identifies goals and purpose of project • Demonstrates understanding of topics and concepts represented in the project • Selects an appropriate method of constructing and creating project • Uses research and information gathered appropriately and effectively in the project • Demonstrates ability to summarize and synthesize infor-mation within the project • Displays learning with pride in final presentation of project
Proficient 3	• Identifies a project planning strategy and process • Identifies purpose of project • Selects information relating to topics and concepts under study for the project • Selects an appropriate method of constructing and creating the project • Uses research and information gathered appropriately and effectively in the project • Demonstrates ability to summarize information within the project • Displays learning appropriately in final presentation of project
Acceptable 2	• Uses a previously identified project planning strategy and process • Selects information relating to topics and concepts under study for the project • Selects a method for constructing and creating the project • Uses research and information gathered throughout the project • Displays learning adequately in final presentation of project
Limited 1	• Selects information relating to topics and concepts under study for the project • Constructs and creates the project using an identified approach • Uses information gathered for the project

RUBRIC

Excellent 4	
Proficient 3	
Acceptable 2	
Limited 1	
No work completed 0	

LESSON SEQUENCE ONE: ANALYZE THIS

Overview

In Lesson Sequence One, students focus on the production of biodiesel and associated chemical processes and properties. Students learn from, and experiment with, the properties of canola oil to expand their understanding of titration. They consider the implications of canola's flash point and molecular composition compared to other feedstock choices.

Rationale

Students should understand the chemical processes associated with biodiesel production. They should also start to identify some of the chemical properties of biodiesel and consider issues and decisions associated with its use.

Presenting students with "I can…" statements can help focus their learning and provide a context for assessment with this lesson sequence's activities.

Inquiry

How do the properties of biodiesel make it an alternative fuel source?

Key Concepts

Biofuels · *Biodiesel* · *Cloud point* · *Melting point*
Indicator · *Base* · *Titration* · *Catalyst* · *Combustion*
Iodine value · *Viscosity* · *Triglyceride* · *Esters*
Methanol · *Glycerine* · *Transesterification* · *Reaction*

Preparation

Suggested Time: 3 to 4 80-minute class periods

The following handouts, materials and resources are used in this lesson sequence:

- Handouts
    - o Briefing Notes 1A: Analyze This
    - o Student Resource 1B: KWHL Chart
    - o Student Resource 1C: Flow Chart
- Chart paper

Student Resource 1D: Extend and Apply – Addition Reactions and Iodine Values

"I CAN"

Lesson Sequence One encourages students to demonstrate their learning by developing understandings such as the following:

- ***I can*** *analyze the meaning and implications of biofuel production on energy consumption and production.*
- ***I can*** *identify and describe processes used to produce biodiesel.*

- Student lab materials

  Physical Properties of Vegetable Oils Lab:

  - o Coconut oil (Available from health food stores or stores that sell spa product ingredients.)
  - o Peanut oil (Substitute with a different oil, such as corn oil or lard, if there are students with peanut allergies in your classroom.)
  - o Canola oil
  - o Soybean oil (Substitute with a different oil, such as corn oil or lard, if soybean oil is difficult to obtain.)
  - o Disposable plastic pipettes or graduated cylinders
  - o 25 mL Erlenmeyer flask (4 per student lab group)
  - o 250 mL beakers (4 per student lab group)
  - o Ice
  - o Wide popsicle sticks, a board or similar material

  Titration Lab:

  - o Samples of fresh and used canola oil (If used frying oil is not available, create used oil by heating it until it turns brown. Consider obtaining some from the cafeteria, or from a local fast food establishment, if canola oil is used for cooking.)
  - o 99% isopropanol solution (IPA)
  - o Titrant – 0.1% solution of sodium hydroxide (1 g NaOH added to 1 L of water or 0.025 moles/litre of titrant)
  - o pH indicator (phenolphthalein, turmeric or other indicator able to indicate pH 7.0)
  - o Clean sample cup (100 mL Erlenmeyer flask or plastic sample cup)
  - o Disposable plastic pipettes or graduated cylinders capable of an exact measurement of 1 mL of oil
  - o Burette

- Demonstration lab materials

  Biodiesel Test Batch Lab:

  - o 300 mL of canola oil
  - o Safety goggles, gloves, apron
  - o Hot plate or hot water bath
  - o Magnetic stirrer (optional)
  - o Stir bars (optional)
  - o Beakers (500 mL + 125 mL)
  - o 100 mL Erlenmeyer flask
  - o Methanol (may be labeled methyl hydrate in stores)

    NOTE: Use care – flammable and toxic.
  - o Lye (sodium hydroxide (flake or pellets), aka NaOH)

NOTE: Use care – very caustic and hydroscopic (Keep in a dry sealed container – this is very important as it cannot be exposed to moisture or results will not be accurate. Dissolving NaOH in water is exothermic; it can become very hot.)

- o Distilled water

- Optional Extension: Local media and online sources of current events, including any that provide information related to technological and scientific research and development. Ask students to suggest website links or bring copies of media sources from home to establish a classroom collection.
- Internet access and interactive whiteboard to display and share website links

__Chemistry 20__ and __ICT__ outcomes are listed in full on pages 2 and 3.

Inquiry

Analyze This

How do the properties of biodiesel make it an alternative fuel choice?

***Attitude Outcomes**

that support the responsible acquisition and application of knowledge related to science and technology are also developed and supported by this resource.

Knowledge Outcomes

- **20–A2.1k**
- **20–A2.2k**
- **20–A2.6k**
- **20–C1.11k**
- **20–D2.2k**
- **20–D2.6k**

Science, Technology & Society Outcomes

- **20–A2.1sts**
- **20–A2.2sts**
- **20–A2.3sts**
- **20–D1.1sts**

Skill Outcomes

- **20–A2.1s (1)**
- **20–A2.2s (2)**
- **20–A2.3s**
- **20–C2.3s (1)**
- **20–D2.2s (1)**

ICT Outcomes

C.1 Students will access, use and communicate information from a variety of technologies.

- **ICT–C1 4.1**
- **ICT–C1 4.2**
- **ICT–C1 4.3**
- **ICT–C1 4.4**

C.2 Students will seek alternative viewpoints, using information technologies.

- **ICT–C2 4.1**
- **ICT–C2 4.2**

C.3 Students will critically assess information accessed through the use of a variety of technologies.

- **ICT–C3 4.1**
- **ICT–C3 4.2**

Lesson Sequence One
Chemistry 30 Curriculum Connections

Inquiry

Analyze This

How do the properties of biodiesel make it an alternative fuel choice?

__Chemistry 30__ and __ICT__ outcomes for Lesson Sequence One are listed in full on pages 4 and 5.

***Attitude Outcomes**

that support the responsible acquisition and application of knowledge related to science and technology are also developed and supported by this resource.

Knowledge Outcomes

- **30–A2.2k**
- **30–A2.3k**
- **30–A2.4k**
- **30–C1.4k**
- **30–C1.7k**
- **30–C2.1k**
- **30–C2.2k**

Science, Technology & Society Outcomes

- **30–A2.1sts (ST1) [ICT F2–4.4]**
- **30–C1.1sts; 30–C2.1sts (SEC1) [ICT F2–4.4, F2–4.8]**
- **30–C2.2sts (SEC2) [ICT F2–4.8]**
- **30–C2.3sts (SEC3) [ICT F3–4.1]**

Skill Outcomes

- **30–A2.1s; 30–C1.1s; 30–C2.1s**
  ***IP–ST2**
  ***IP–NS1, IP–NS2, IP–NS3**
  ***IP–ST2, IP–ST3**
  ***IP–NS3**
- **30–A2.2s; 30–C1.2s; 30–C2.2s**
  ***IP–NS1, IP–NS2, IP–NS3, IP–NS4**
- **30–A2.3s; 30–C2.3s**
  ***AI–NS1**
  ***AI–ST2 [ICT F3–4.1]**

ICT Outcomes

C.1 Students will access, use and communicate information from a variety of technologies.

- **ICT–C1 4.1**
- **ICT–C1 4.2**
- **ICT–C1 4.3**
- **ICT–C1 4.4**

C.2 Students will seek alternative viewpoints, using information technologies.

- **ICT–C2 4.1**
- **ICT–C2 4.2**

C.3 Students will critically assess information accessed through the use of a variety of technologies.

- **ICT–C3 4.1**
- **ICT–C3 4.2**

Lesson Sequence One Teaching and Learning Strategies

How do the properties of biodiesel make it an alternative fuel source?

Introductory Activity

Students begin with a brainstorming activity in which they think about and discuss what they know about the production and use of biofuels, as well as their benefits or drawbacks. They are encouraged to identify and consider what they already know and question whether their existing knowledge is based on assumption, first-hand experiences, scientific fact or media messages.

Instructional Strategy: Board Share

A board share is a cooperative learning activity that encourages students to work as a whole class group to brainstorm ideas, experiences and insights around a specific topic or question. The board share structure encourages students to generate their own ideas and insights as well as consider, and add to, the ideas of others in the class.

A board share strategy asks students to work in small groups and brainstorm responses to a question. While the group brainstorms, an appointed recorder records the group's ideas on the board. The recorder is responsible for ensuring that all of the group's ideas are recorded.

DIFFERENTIATE

If necessary, use a whole class discussion to discuss concepts related to fuels, non-petroleum based fuels, biofuels, biofuel production and quality of life. Work with the class to introduce and record general definitions of some more specific key terms and vocabulary – carboxylic acids, esters, free fatty acids, glyceride, titration and transesterification.

Then, ask students to discuss their perception of the relationship between fuel production and technology, listing key terms associated with this relationship on the board.

PROCESS

1. Introduce the critical issue to students by writing it on the board: *To what extent would increased production and use of biofuels make a difference to quality of life?* Tell students that they will be starting to explore this question in the context of biofuel production and the implications of chemistry in its production as well as its uses.

2. Have students form small groups and use a group share strategy such as a board share to record ideas in the form of a brainstorming web on the board, interactive whiteboard or chart paper. Pose questions such as the following to students:
   - What do you know about renewable fuels, such as biofuel, and their use? How do you know this?
   - What are some benefits of considering renewable, alternative fuel sources? How do you know these benefits are valid?
   - What are some potential risks, safety or waste issues? How do you know these risks or issues are valid?

3. Discuss the resulting ideas and ask students to relate them back to the inquiry question for this lesson sequence, *How do the properties of biofuel make it an alternative fuel choice?* Ask students to consider where their knowledge of alternative energy or fuel sources comes from and discuss how this knowledge can be validated through understandings and applications of chemistry processes and principles.

4. **Extend:** Ask students to explore issues related to alternative energy and fuel sources and implications resulting from the development of new technologies in this field. Use a variety of online and print media

sources, such as newspapers, magazines or internet sites. Have students work with a partner or in a small group to identify those that have resulted from or in increased scientific research. Encourage students to discuss the role of the media in disseminating information about scientific and technological developments. How does the media, including the internet, promote attitudes and knowledge about these developments? What effects do these sources of information have on issues and decisions about the use of alternative energy sources?

Ask students to brainstorm additional applications of alternative energy sources. Compare these ideas to research collected from different sources, such as internet or classroom textbook resources. How are traditional sources of fuel used? How many potential different applications could an alternative energy source like biofuels have?

Ask students what, if any, experiences they have had in researching the implications and properties of biofuels and biodiesel in Chemistry 20. If students have previously completed biodiesel labs in Chemistry 20, consider selecting and implementing the activities in this lesson as a review and reinforcement of concepts related to chemical properties and reactions. Alternatively, use the Briefing Notes Activity and labs in their entirety to lead into the Chemistry 30 extension and application activity.

Briefing Notes Activity

Students start the Briefing Notes with a simple lab, designed to encourage them to consider the different physical and chemical properties and changes of four different vegetable oils. They continue to read and discuss information on biofuels in the Briefing Notes with a partner. They then explore the implications of the biofuel composition to its proposed uses.

Instructional Strategy: Comparative Analysis and Lab Work

Developing skills of comparative analysis can be facilitated through experiential labs that encourage comparison and the quantitative analysis of data.

PROCESS

1. Provide each student with a copy of **Briefing Notes 1A: Analyze This.** Assign individually, or work with students to discuss or respond in writing to the *Predict* questions at the beginning of the student resource.

2. Have students work with a partner to complete the **Physical Properties Lab,** in which they are asked to determine the physical properties of different vegetable oils and compare changes in matter.

FIND INFORMATION

There are a plethora of internet sites, articles and blogs related to alternative energy sources, including biodiesel and other biofuels. It is important that students are asked to evaluate the validity and source of the information presented in these sources. Some weblinks that provide information and perspectives on the use and issues associated with alternative energy sources, current at the time of printing, include the following:

- *Canola Council of Canada website, found at www.canolacouncil.org/canola-biodiesel/.*
- *National Research Council Canada website article*, Canada flies the world's first civil jet powered by 100 percent biofuel, *at www.nrc-cnrc.gc.ca/eng/news/releases/2012/biofuels.html.*
- *Canadian Renewable Fuels Association website:* Ethanol and Biodiesel – Growing Beyond Oil, *found at www.greenfuels.org/.*
- *Natural Resources Canada website:* Alternative Fuels, *found at http://oee.nrcan.gc.ca/transportation/alternative-fuels/780.*
- *The World Bank website:* Biofuels: The Promise and the Risks, *found by searching on http://econ.worldbank.org/.*
- *A number of articles relating to the use of biofuels, particularly from a European and international perspective, available at www.spiegel.de/international/topic/biofuel/.*
- *Issues dealing with world food, biofuel and food security on the United Nations website, found at www.un.org.*

Note: Students are also provided with these weblinks in the Briefing Notes Activity.

FIND INFORMATION

A number of videos about biodiesel, how it is made and how it is used are provided on the Utah Biodiesel Supply website at http://utahbiodieselsupply.com/tutorialvideos.php.

Physical Properties Lab

This simple lab encourages students to visualize physical changes in matter by investigating melting point, cloud point and gel point comparisons between different vegetable oils. Provide students with four "unknown" oils on which to perform the tests outlined in the lab instructions. The coconut oil has a melting point close to room temperature and will solidify when it cools slightly. When cooled over ice, oils with a high saturated fatty acid content, such as the coconut and peanut oils, will solidify first. The canola oil and soybean or corn oil should not solidify as readily as their melting points are below and near freezing. Discuss other distinguishing properties of the oils, such as density, viscosity and colour. (Note: Substitute peanut oil with a different oil if there are students with peanut allergies in your classroom.)

3. Complete the **Titration Lab** to compare the level of free fatty acids present in fresh canola oil and used frying canola oil.

Titration Lab

This simple lab encourages students to compare the levels of fatty acid between fresh and used canola oil – students will need access to samples of each. Detailed instructions for students to conduct this lab are provided in the Briefing Notes. Alternatively, directions for demonstrating this lab are provided below. Students will start with 10 mL samples of the fresh and used canola oil, a pH indicator (able to indicate a pH of 7.0), IPA (isopropyl alcohol) and a disposable plastic pipette or graduated cylinder. Students measure out a 1 mL sample of the canola oil. It is extremely important that this measure is accurate. The fresh canola oil should change colour with one drop of the titrant, while the used oil will take several mLs of the titrant. Discuss the implications of increased presence of free fatty acids in used oil.

BIODIESEL TITRATION LAB

This assay measures the level of free fatty acids present in oil and therefore determines the amount of additional sodium hydroxide that needs to be added during the reaction to neutralize the oil.

NOTE: Students may be asked to complete more than one trial, then average the results.

Materials

- Samples of fresh and used canola oil (If used frying oil is not available, create used oil by heating it until it turns brown. Consider obtaining some from the cafeteria, or from a local fast food establishment, if canola oil is used for cooking.)
- 99% isopropanol solution (IPA)
- Titrant – 0.1% solution of sodium hydroxide (1 g NaOH added to 1 L of water or 0.025 moles/litre of titrant)
- pH indicator (phenolphthalein, turmeric or other indicator able to indicate pH 7.0)
- Clean sample cup (100 mL Erlenmeyer flask or plastic sample cup)
- Disposable plastic pipettes or graduated cylinders capable of an exact measurement of 1 mL of oil
- Burette

Test Method

1. Measure 10 mL of 99% isopropanol solution into an Erlenmeyer flask.
2. Add a small amount of pH indicator to the solution (3 drops of phenolphthalein or a dusting of turmeric powder).
3. Use a disposable plastic pipette or graduated cylinder to measure exactly 1 mL of oil and pour it into the flask.
4. Stopper the flask and mix the solution of alcohol and oil by shaking it gently.
5. Fill a burette with the titrant (0.1% NaOH).
6. Slowly add the titrant to the Erlenmeyer flask and mix during addition.
7. Stop adding the titrant once pH =7 is determined by the colour change. For example if using tumeric, the colour changes from yellow to pink. If the solution remains pink for at least 10 seconds the pH is 7; if the colour turns bright red, too much titrant was added and it is necessary to start over.
8. Record the amount in mL of titrant added to create a colour change.
9. This value (acid number) indicates the amount of additional NaOH required to neutralize the free fatty acids in g/L.
10. Calculate the amount of NaOH required to conduct the reaction using the following equation – NaOH required (g/L of oil) = 3.5 + acid number.

Example if 2 mL of solution is required, acid number = 2

3.5 + 2 = 5.5 g NaOH/L of oil

4. Provide the Biodiesel Test Batches demonstration that follows to explore the catalyst measure and production, transesterification reaction and glycerol separation processes in the production of biodiesel. Note: This process is not provided in the Briefing Notes, but can be provided to students if they complete this lab independently.

BIODIESEL TEST BATCHES DEMONSTRATION LAB

Materials

- 300 mL of canola oil
- Safety goggles, gloves, apron
- Hot plate or hot water bath
- Magnetic stirrer (optional)
- Stir bars (optional)
- Beakers (500 mL + 125 mL)
- 100 mL Erlenmeyer flask
- Methanol (may be labeled methyl hydrate in stores).

  NOTE: Use care – flammable and toxic

- Lye (sodium hydroxide (flake or pellets), aka NaOH)

  NOTE: Use care – very caustic and hydroscopic (Keep in a dry sealed container – this is very important as it cannot be exposed to moisture or results will not be accurate. Also note that dissolving NaOH in water is exothermic; it can become very hot.)

- Distilled water

Method

1. Measure 300 mL of oil into 500 mL beaker.

Catalyst Production

2. Weigh 2.1 g of lye into a 125 mL beaker.
3. Add 65 mL of methanol and stir bar to the 125 mL beaker. Alternatively, the solution can be shaken in a stoppered Erlenmeyer flask. Safety Note: Use extreme caution, as this mixture is toxic and flammable.
4. Label this solution "methoxide catalyst."
5. Mix until the lye is dissolved in the methanol. Point out that this solution, the methoxide, is the catalyst needed for biodiesel production. Note: This mixture should be covered with tin foil, as the solution will evaporate very quickly.

Biodiesel (Transesterification) Reaction

6. Pour the methoxide catalyst into oil. Heat it by placing the beaker into a hot water bath, or place on hot plate and heat to 55 °C. Note: You can set the hot plate at 180 °C until mixture reaches 50 °C then turn plate down to 60 °C.
7. Hold at 55–60 °C for 20–45 minutes. Do not take this over its boiling point – the methanol has a fairly low boiling point.

Glycerol Separation Options

8. Use a disposable plastic pipette to decant the biodiesel off and leave the glycerol byproduct behind.

   OR Transfer the mixture into a separatory funnel (close vale first!). Let the glycerol settle to bottom for at least an hour. The mixture should separate into two distinct layers, with the biodiesel on top and the heavier glycerol on the bottom. Safety Note: The glycerol contains lye and methanol so it is both caustic and flammable at this point. Drain the glycerol into a 125 mL funnel.

   OR Repeat reaction with 0.5 g of lye and 20 mL of methanol for 30 minutes, settle and remove glycerol.

Biodiesel Washing Options

9. Add 100 mL warm (40 °C) distilled water to separatory funnel and mix gently. Let the mixture settle and pour off the bottom fraction (soapy water). Repeat four times, starting by mixing very gently and then more vigorously with each wash.

Polishing and Drying Biodiesel (Alternative method)

10. Place biodiesel in beaker, add 5 mL scoop of ion exchange resin Purolyte PD206 and stir bar. Stir for 10 minutes and heat to 50 °C. If the mixture is not completely clear, add an additional 5 mL of resin and stir until completely clear. Filter the dried biodiesel into sample cup.

    OR If you have a magnetic stirrer you can dry the biodiesel by heating it up to 120 °C. It must be in something that is stirring constantly and bringing water up to the surface, such as a magnetic stirrer/heater.

NOTE: Purolyte can be obtained through the following sources:

Purolite Co.
150 Monument Rd
Bala Cynwyd, PA, USA, 19004

Purolite Canadian Sales
PO BOX 308
Paris, Ontario, N3L 3G8

Tel: 1-519-448-4665
canadiansales@puroliteusa.com

5. Ask students to continue their investigations by reading the Briefing Notes and exploring the questions and information provided. These questions include:
   - What are the physical and chemical properties of biodiesel?
   - How do these properties of canola make it suitable for use as biodiesel? *(Encourage students to consider benefits beyond biodiesel as just an alternative energy source. Consider the effects of biodiesel on engine life of diesel engines.)*
   - What is the chemistry of biodiesel?
   - Is biodiesel a viable alternative to fossil or petroleum fuels?

6. **Extend:** Ask students to work with a partner to research the growing locations of different seed crops. What correlation, if any, can you find between the gel point of each seed to the climate in which it is grown? Alternatively, research the different types of feedstock – hemp, algae, stinkweed, used coffee grounds, etc. – that can be used to make biodiesel. What are the energy input and output implications for each type of feedstock?

Provide students with **Student Resource 1D: Extend and Apply – Addition Reactions and Iodine Values.** Have students work with research or lab groups to complete the activities in the student resource.

Closing Activity

Students complete a KWHL chart that focuses on the issue of balancing the application of technology with the protection of biological diversity. They apply what they have learned from the Briefing Notes to the development of further research questions.

Instructional Strategy: KWHL Chart

Group discussion, analysis and synthesis of information encourage students to draw conclusions and ask questions that lead to further research. Using a visual organizer such as a KWHL chart, students link their prior knowledge and understandings to ideas for further research.

DIFFERENTIATE

Providing the KWHL chart at this point in the lesson provides students with the opportunity to reflect on what they have learned from the Briefing Notes as well as identify questions they have for further research. The KWHL chart can also be used to identify the different interests and learning supports that individual students have. To complete the KWHL chart, provide students with the following choices:

- *Completing the chart on their own*
- *Completing the chart in a small group*
- *Working with you to complete the chart.*

PROCESS

1. Present the following questions to students as a class, asking them what insights they have gained from the information they explored in the Briefing Notes:
    - What are the possible issues and controversies in the changing ways society produces and consumes fuels?
    - What future impact might biofuel technology have on fuel production and consumption?
2. Revisit the critical issue: *To what extent would increased production and use of biofuels make a difference to quality of life?* Have each student complete **Student Resource 1B: KWHL Chart.** Trade the chart with another student and discuss ideas that are similar and different.
3. Have students in small groups discuss and record their responses to the question.
4. Ask small groups to share their perspectives, responses and ideas with the whole class.
5. Ask students to consider how they think scientific research related to genetics and increasing uses of different types of technologies have impacted, or resulted in changes to society and the environment. In addition to the questions students have brainstormed in their KWHL charts, work with the class to shape and refine potential focus questions for further research, such as:
    - To what extent has society's growing concern over alternative energy sources, including fuel, affected and changed the ways society uses its resources?
    - How have energy producing industries applied knowledge and new technologies resulting from chemistry research and principles?
    - What impact has scientific research and technology had on the range of choices for energy?

30

Encourage students to complete the KWHL chart by focusing on the implications of properties such as melting point and iodine values for the range of uses, practicality and future potential of biofuels for society as a whole.

Extension Activity

Students work with a partner or individually to research and design or illustrate processes used for the home-based industry that exists for biodiesel production.

Instructional Strategy: Flow Chart

A flow chart is a graphic organizer that is used to describe and detail processes, facilitating analysis and comparisons.

PROCESS

1. Invite students to research the extent of the "home brewed" biodiesel production industry.
2. Provide students with **Student Resource 1C: Flow Chart.** Ask students to work individually or with a partner to flow chart the processes used to produce "home brewed" biodiesel. What are lessons learned and insights that could apply to widespread production of biodiesel?
3. Invite students to present and share their projects with others in the class.

DIFFERENTIATE

Students can be provided with the choice of working individually, with a partner, or in a small group. Students can also be provided with a number of choices for presenting their product – poster, PowerPoint slides, acetate sheet overlays or an animated webpage.

Find Information

The Collaborative Biodiesel Tutorial
www.biodieselcommunity.org/

This site provides simple-to-follow information on making biodiesel and homebrewing equipment by people from all around the world who make biodiesel.

Biodiesel Now
www.biodieselnow.com

This site provides a wide range of information related to biodiesel. Topics are organized by type and include Biodiesel in the Press, Biodiesel Production, Advanced Production Techniques and Biodiesel Vehicles.

Iowa State University Biorenewables Research Laboratory
www.engineering.iastate.edu/brl/educationlabs/activities/

The Biorenewables Education Lab provides lab activities related to biodiesel and include online access to an instructor's and participant's guide.

Analyze This

Predict

How much potential do you think biofuels have for replacing petroleum-based energy sources? Why do you think this?

____

____

____

____

DID YOU KNOW?

Adding 160 million kilograms of canola oil lubricant could save 1.1 billion kilograms of diesel fuel and prevent the emission of 3 billion kilograms of carbon dioxide into the atmosphere!

Find out more about biodiesel on the Canola Council of Canada website at www.canolacouncil.org/canola-biodiesel/canola-biodiesel/.

Biofuels? Biodiesel? Ethanol?

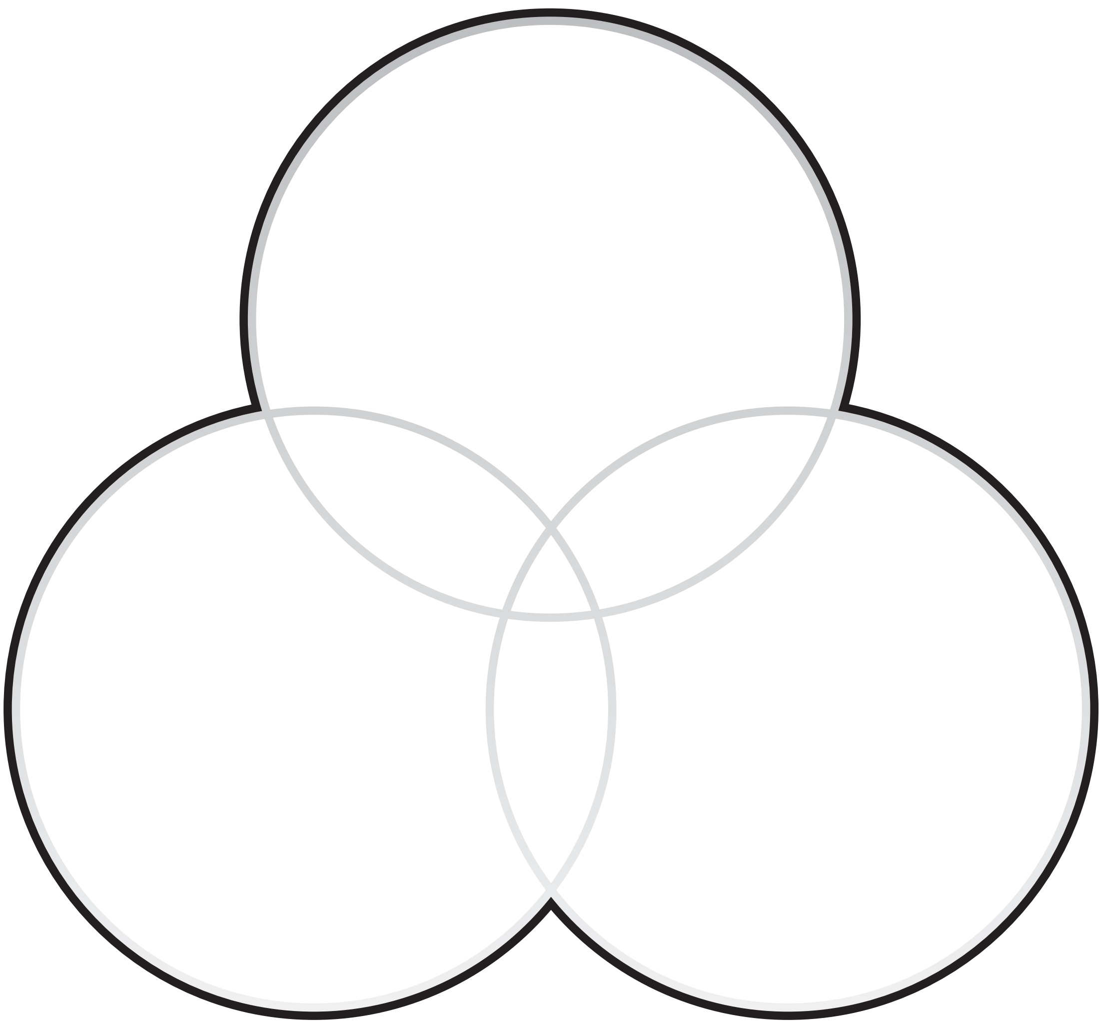
We hear these words more often as people around the world move toward the use of **biofuels**, which can be replenished from locally grown crops, to partially replace **petroleum**, a non-renewable resource. There's no doubt that the biofuels industry has the potential to be good for the economy as new plants are built, jobs are created and farmers' incomes rise. Many countries around the world, including Canada and the United States, are looking at "clean" fuel alternatives, including biofuels. Many believe that biofuels – and biodiesel – provide opportunities to reduce greenhouse gas, increase income and employment in rural communities and provide more consumer choice of fuel sources.

In both Canada and the United States, federal, provincial and state governments have set new standards for the production of environmentally sustainable energy sources. Many of the machines that "power" the Canadian economy – heavy equipment, long haul trucks, farm machinery, government vehicles and generators – are powered by diesel fuel. As of July 2012, all diesel fuel sold in Canada is required to contain 2 percent biodiesel. The Canadian government has also stated a goal that all fuels will eventually have 5 percent renewable content. It is expected that substituting just 5 percent of the diesel used today with Canadian-produced biodiesel will generate more production and result in additional farm income.

What exactly is biodiesel? **Biodiesel** can be defined as the mono-alkyl esters of fatty acids derived from vegetable oils or animal fats. In other words, biodiesel is the product you get when a vegetable oil or animal fat is chemically reacted with an alcohol to produce a new compound that is known as a **fatty acid alkyl ester**. A catalyst such as sodium or potassium hydroxide is required, and glycerol is produced as a byproduct.

EXPLORE

What benefits do you think biodiesel has compared to the use of traditional diesel fuel? What do you think the drawbacks might be? Use a Venn diagram to compare benefits and drawbacks, placing benefits or concerns common to both biodiesel and traditional diesel in the intersection of the circles.



What properties do you think vegetable oils should have to be considered for biofuels? Try the lab that follows.

LAB: *Properties of vegetable oils*

Which vegetable oils are suitable for use as biodiesel? What properties do you think oils should have in order to be appropriate for use as fuel for diesel engines? The temperature at which an oil solidifies affects its suitability for use as fuel. As vegetable oils cool, wax crystals form and the oil clouds. This is called the **cloud point** of the oil. **Viscosity**, or the flow rate of the oil, is also a factor that affects suitability for use as a biofuel.

Why do you think the cloud point and viscosity are important to know? Use the lab procedure below to explore some vegetable oils that are similar to those actually used as biodiesel.

1. Use the four different types of vegetable oils provided. Almost all oils and fats are made primarily from different mixtures of triglycerides, which solidify at different temperatures. As the oil is cooled from its melting point, the triglycerides solidify, causing the oil to become cloudy and thicken, before it finally solidifies completely. These cloud points are indicated in the chart below.

Vegetable Oil	Approximate Cloud Point (ºC)
Coconut Oil	25 ºC
Peanut Oil	3 ºC
Canola Oil	-10 ºC
Soybean Oil	-16 ºC
Corn Oil	11–14 ºC

2. To identify each oil, you will have to design an experiment in which you determine the cloud point of the four vegetable oils. Record the method you will use below.

3. Using an incline created by wide popsicle sticks, a board or similar material, design a simple procedure in which you drip the oil and record the time it takes for the oil to flow to a set point on the incline. What does this tell you about the viscosity of each oil?

4. Record your results in the second and third columns of the observation chart.

Vegetable Oil	Cloud Point Data	Viscosity Data
1		
2		
3		
4		

5. What physical changes do you observe while testing the oils? Note these in the chart below.

Vegetable Oil	Physical Properties Before	Physical Properties After
1		
2		
3		
4		

6. Physical changes do not change the structure of molecules; rather they change the state of the matter. A physical change occurs when the state of a substance is changed while its chemical properties remain the same, or constant. The oils in this experiment are still oils, but in a different form. How is this similar to ice and water?

7. A chemical change results in a change in the chemical composition of a substance. The oils used to produce biodiesel must be suitable for use in an internal combustion engine where fuel is burned to produce energy. When it is burned, the fuel is changed by being converted to carbon dioxide and water. Which of the four oils would you recommend for use in a biodiesel engine? Why?

Why do the physical and chemical properties of canola make it suitable for biodiesel?

Biodiesel can be made from a variety of feedstocks, including vegetable oil, animal fats or recycled restaurant grease, also known as “yellow grease.” The Canadian-based biodiesel industry tends to include higher levels of canola because of its unique characteristics. These characteristics include:

- High oil content
- Low levels of saturated fat
- Iodine values averaging 114.

DID YOU KNOW

Biodiesel should not be confused with ethanol. Although both are biofuels, biodiesel is produced from oils, such as canola, soy and palm, and can be used in diesel engines. Ethanol is produced from cereals such as corn and wheat, and is used in gasoline engines.

The **iodine value (IV)** is the value of the amount of iodine, measured in grams, absorbed by 100 grams of a given oil. Iodine value is commonly used as a measure of the chemical stability of different biodiesel fuels.

Canola is an oilseed crop which is grown annually by Canadian farmers on approximately 14 million acres across the prairies and Ontario. When the seed is processed it produces 43 percent oil and 57 percent meal, a high protein animal feed. The oil is further processed into products such as margarine and cooking oil. It can also be made into biodiesel.

Since 1994, the average oil content of canola has exceeded 42 percent. The high oil content means more oil is available per unit of seed, which ultimately makes more of the feedstock available for biodiesel production and produces less byproduct relative to other oilseeds. As a result, a biodiesel producer can obtain more oil from canola than from other oilseeds with lower oil contents, for example, compared to soybeans.

FIND INFORMATION

Watch a classroom in Alberta that makes their own biodiesel on www.teachertube.com. Use the link below, or search for “biodiesel.”

http://teachertube.com/viewVideo.php?video_id=29187

In biodiesel, low saturated fat content is linked to improved cold weather performance. At low temperatures, petroleum diesel can gel or crystallize and cause the engine to stop, which is why diesel truck operators will often leave their vehicles idling, instead of stopping and restarting the engine on very cold days. One measure of fuel performance is the cloud point. Canola has the lowest level of saturated fats at 7 percent and the resulting biodiesel has a cloud point of –3°C. Soybean oil biodiesel will begin to form crystals at 3 °C, while the cloud point for diesel made from edible tallow is 19 °C.

Iodine value is a measure of oxidative stability. Oxidation can lead to the formation of corrosive acids and deposits that cause increased wear in engine fuel pumps and fuel injectors. In general, the lower the IV, the more stable the oil, the less oxidation and the lower the engine deposits. The IV for canola is 114 and over 130 for soybean oil.

Density refers to the weight per unit volume and is commonly expressed in kilograms per cubic meter. Oils that have a higher density contain more energy. The greater the fuel density, the greater the mass of fuel that can be stored in a tank. Petroleum and diesel fuels provide comparable energy by weight. However, diesel is denser and therefore provides more energy per litre.

EXPLORE

The following graphs provide additional comparisons between canola oil and other vegetable oils. What conclusions can you draw from these graphs regarding the suitability of canola oil for the production of biodiesel?

Figure 1: Effect of Temperature on Density of Selected Oils. Adapted from Lang, et al (1992) and Noureddini, et al (1992)

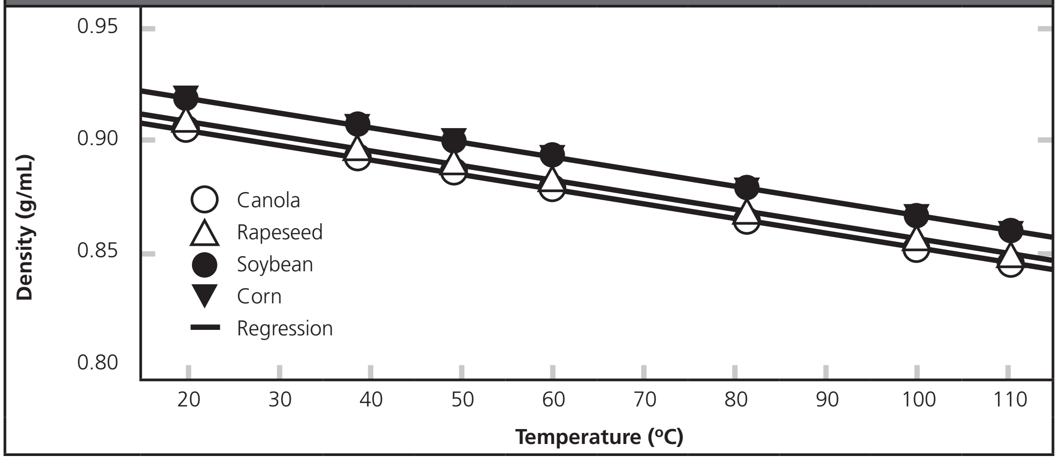
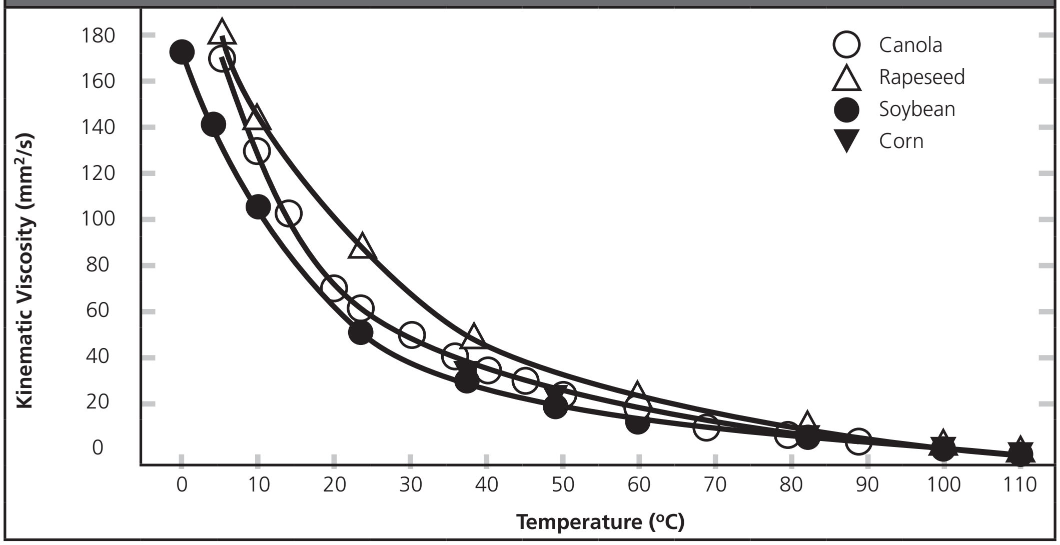


Figure 2: Effect of Temperature on Viscosity of Canola and Selected Oils. Adapted from Lang, et al. (1992), Vadke et al. (1988) and Noureddini et al. (1992)



LAB: *Titration*

If you were to look at a sample of used cooking or frying oil, could you tell how many free fatty acids are present?

When an oil is heated repeatedly over an extensive period of time, it breaks down to free fatty acids. It is difficult to identify whether any, or how many, fatty acids are present just by looking at the oil! However, it is important to know how much acid is present so it can be removed. Adding a base to the oil until the pH is neutral can give you this information. The more base that has to be added, the more acid is present in the oil. The process of testing for fatty acids is called **titration.**

Use the two samples of cooking oil provided. Test **each** sample using the following procedure.

1. Measure 10 mL of 99% isopropanol solution into an Erlenmeyer flask.
2. Add a small amount of pH indicator to the solution (3 drops of phenolphthalein or a dusting of turmeric powder).
3. Use a disposable plastic pipette or graduated cylinder to measure exactly 1 mL of oil and pour it into the flask.
4. Stopper the flask and mix the solution of alcohol and oil by shaking it gently.
5. Fill a burette with the titrant (0.1% solution of NaOH – 1g or NaOH added to 1 L of water or 0.025 mol/L of titrant).
6. Slowly add the titrant to the Erlenmeyer flask and mix during each addition. Continue to add drops of the titrant until each oil mixture starts to change colour. Stop when you see a pale pink colour that remains for 30 seconds when you shake the oil mixture. If the mixture turns bright pink, you have added too much titrant and you will have to start over!
7. Repeat the procedure for the second sample.
8. Use the charts that follow to record the results of the procedure.

Fresh Canola Oil

Trial	Final Burette Volume (mL)	Initial Burette Volume (mL)	Total Volume Used (mL)	Endpoint Colour
1				
2				
3				
Averages				

Overcooked Canola Oil

Trial	Final Burette Volume (mL)	Initial Burette Volume (mL)	Total Volume Used (mL)	Endpoint Colour
1				
2				
3				
Averages				

9. What does this procedure tell you about used cooking or frying oil? How do the average total volumes compare?

10. What implications you think this procedure has for biodiesel production?

EXPLORE

Prepare for the biodiesel reaction demonstration lab by completing the following questions.

The titration procedure is a necessary step in the production of biodiesel in order to determine the amount of methanol to be mixed with NaOH and used as a catalyst. Complete the following calculations to determine the amount of catalyst, using your results from the titration you completed earlier. Ensure you complete the calculations for both the fresh oil and the used oil results.

1. Calculate the average titration volume (D).

Titrant in mL	Volume used
Titration 1	**(A)**
Titration 2	**(B)**
Titration 3	**(C)**

Fresh Oil	(**A + B + C**) / 3 = **D** (_________ + _________ + _________) / 3 = _____________________ (D)
Overcooked, or Used, Oil	(**A + B + C**) / 3 = **D** (_________ + _________ + _________) / 3 = _____________________ (D)

2. Calculate the volume of methanol required.

Fresh Oil	**Methanol = 20% of ____________ = .2 x ___________ = ____________ of methanol**
Overcooked, or Used, Oil	**Methanol = 20% of ____________ = .2 x ___________ = ____________ of methanol**

Example

Use 800 mL of oil with a titration amount ***(D)*** *of 1.6 to calculate the amount of methanol required:*

Methanol = ***20% of the volume of oil***

Methanol = 20% of 800 mL = .2 x 800 = ***160 mL of methanol***

3. Calculate the amount of NaOH required.

Example

NaOH in grams = ***(3.5 + (D)) x # Litres of oil***

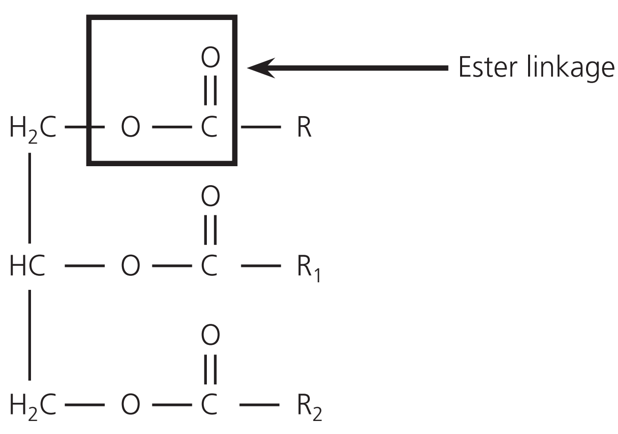
NaOH in grams = ***(3.5 + 1.6) x 0.8 Litres of oil = 5.1 x 0.8 = 4.08 g of NaOH***

Fresh Oil:	**NaOH in grams = (3.5 + ________) x _______ Litres of oil** **= _________ x ________ = _________ g of NaOH**
Overcooked, or Used, Oil	**NaOH in grams = (3.5 + ________) x _______ Litres of oil** **= _________ x ________ = _________ g of NaOH**

The chemistry of biodiesel

All vegetable oils and animal fats consist primarily of triglyceride (oil) molecules. These triglyceride molecules are composed of three fatty acids that are tied to a sugar alcohol, called a glyceride molecule, by an ester bond. This big molecule is called a triglyceride and is thick and slow to move. In this state, it is too thick to use as fuel.

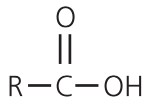
Biodiesel is formed when the triglyceride molecules react with an alcohol such as methanol. **Esters** are a type of chemical compound that contains the following grouping of carbon and oxygen:



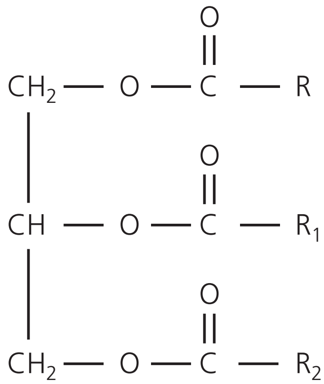
Triacylglyceride (oil or fat)

R1, R2 and R3 represent different hydrocarbon chains of the fatty acid elements of the triglyceride. Because the lengths of the fatty acid chains can vary, the term "R" is used to represent the different lengths of carbon chains. These oils and fats are commonly found in plants and in our bodies.

In their free form, these fatty acids have the molecular composition shown below. The properties of the triglyceride and the biodiesel fuel are determined by the amounts of each fatty acid that are present in the molecules.



[R is a hydrocarbon chain. In biodiesel, R is a hydrocarbon chain of 10 carbon atoms or greater.]



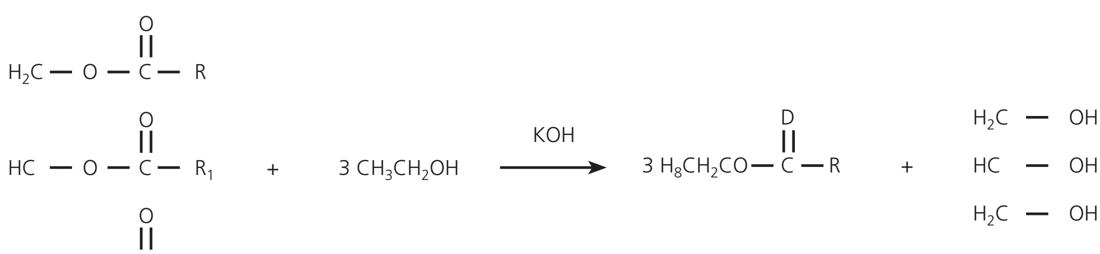
Triaglyceride

When biodiesel is made, the triglyceride molecule is broken into three small pieces, breaking the sugar alcohol (glycerol) free. The glycerol is released but the broken pieces (fatty acids) need to form a new bond. To do this, a smaller alcohol (methanol) is added to bind to each of the molecules so that the molecule is stable again. The result is three smaller molecules that are less viscous, like water, and can be easily used as fuel.

A **monoester** is a molecule that contains only one occurrence of an ester. Other organic molecules can contain more than one occurrence of an ester group, such as the triglyceride shown below.

This molecule contains the ester group three times. Therefore, it is called a **triester.** Sometimes the reaction that converts oil or fat (triglyceride) to methyl esters (biodiesel) is called **esterification.** This is not exactly accurate! Esterification refers to a reaction that converts something that is **not** an ester into an ester.

In reality, the reaction converts one type of ester into another type of ester. This is why the chemical reaction involved in the creation of biodiesel is more properly known as **transesterification.** Transesterification is the process of reacting a triglyceride molecule with an excess of alcohol in the presence of a catalyst (KOH, NaOH, NaOCN3, etc.) to produce glycerine and fatty esters. The tool that is used to take apart the molecules in the production of biodiesel is called a catalyst. To make the reaction, the oil is reacted with a catalyst, alcohol and heat.



EXPLORE

Find out more about canola and biodiesel production, using the sources in Find Information below. Use your research to respond to one of the following questions:

What options do you think might be possible to improve the freezing point characteristics of biodiesel?

One argument that counters the use of biodiesel is that it produces CO_2, which is considered a greenhouse gas. What arguments can be used to counter this issue?

Why do you think the same qualities that make canola good for food also make it good for biodiesel production?

Find Information

Canola Council of Canada website, found at *www.canolacouncil.org/canola-biodiesel*.

Transport Canada website: *Biodiesel in Transit and Municipal Fleets*, found at *www.tc.gc.ca/eng/programs/environment-utsp-biodieselintransitandmunicipalfleets-1067.htm*.

Canadian Renewable Fuels Association website: *Ethanol and Biodiesel – Growing Beyond Oil*, found at *www.greenfuels.org/uploads/documents/crfareportcardenglish2010final.pdf*.

Natural Resources Canada website: *Alternative Fuels*, found at *http://oee.nrcan.gc.ca/transportation/alternative-fuels/780*.

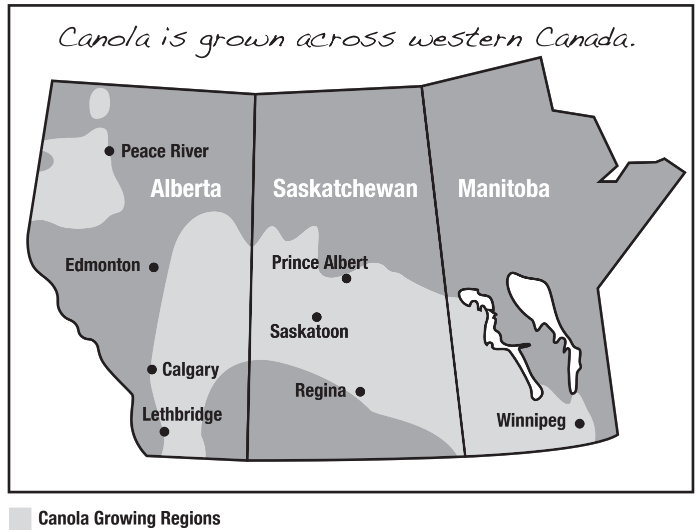
The World Bank website: *Biofuels: The Promise and the Risks*, by searching for the full article title at *www.worldbank.org/*.

EXTEND

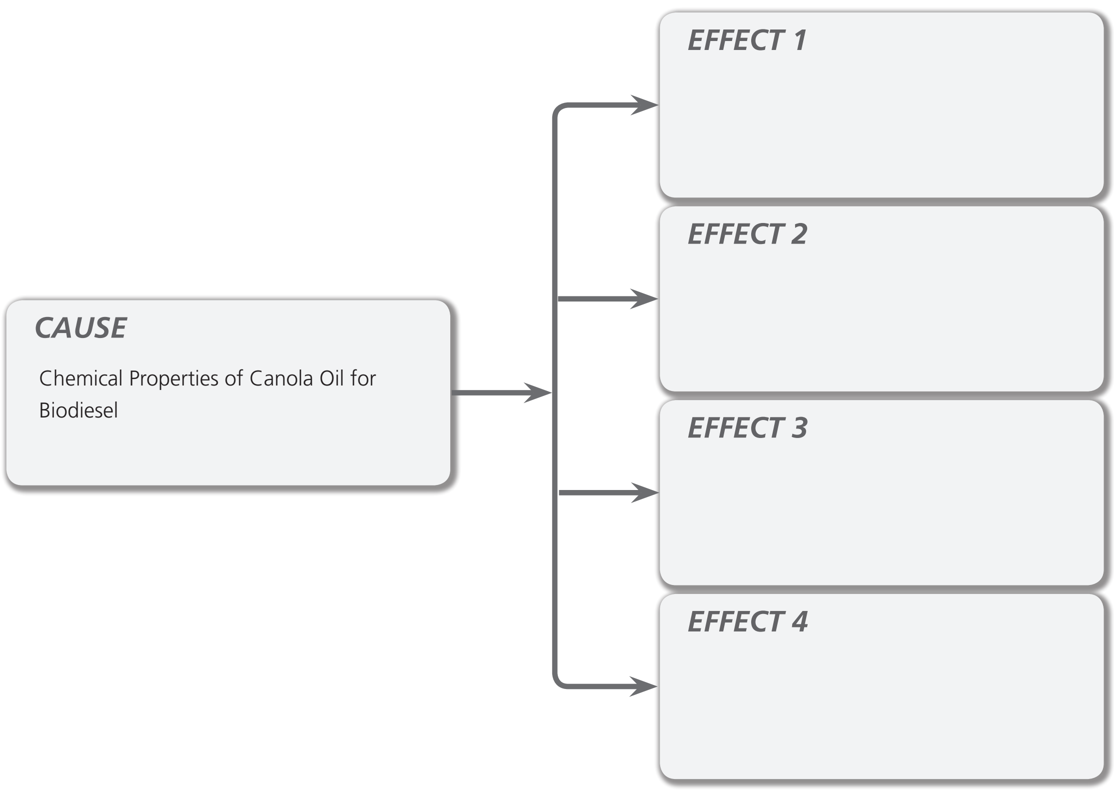
Discuss the following questions with a partner or small group.

What implications do the chemical processes used to produce biodiesel have for its widespread use?

What implications do the properties of canola oil have for its widespread application to biodiesel?



Create a Cause–Effect Chart such as the one below to analyze the potential of canola oil for biodiesel production.



KWHL Chart

To what extent would increased production and use of biofuels make a difference to quality of life?

Biofuels are alternative fuel sources that are described as clean burning, non-toxic and biodegradable. With such obvious benefits associated with these alternative energy sources, why is their use sometimes considered to be controversial? What are the economic, social and environmental implications of biofuel production and consumption? To what extent should biofuel be considered a "better" choice and be produced to replace fossil fuels?

What I Know	
What I Want to Know More About	
How I Will Find This Out	
What I Learned	

DEFINING TERMS

Write your definition for each term:

Biofuels

____

____

____

____

____

Biodiesel

____

____

____

____

____

Titration

____

____

____

____

____

Catalyst

____

____

____

____

____

Reaction

____

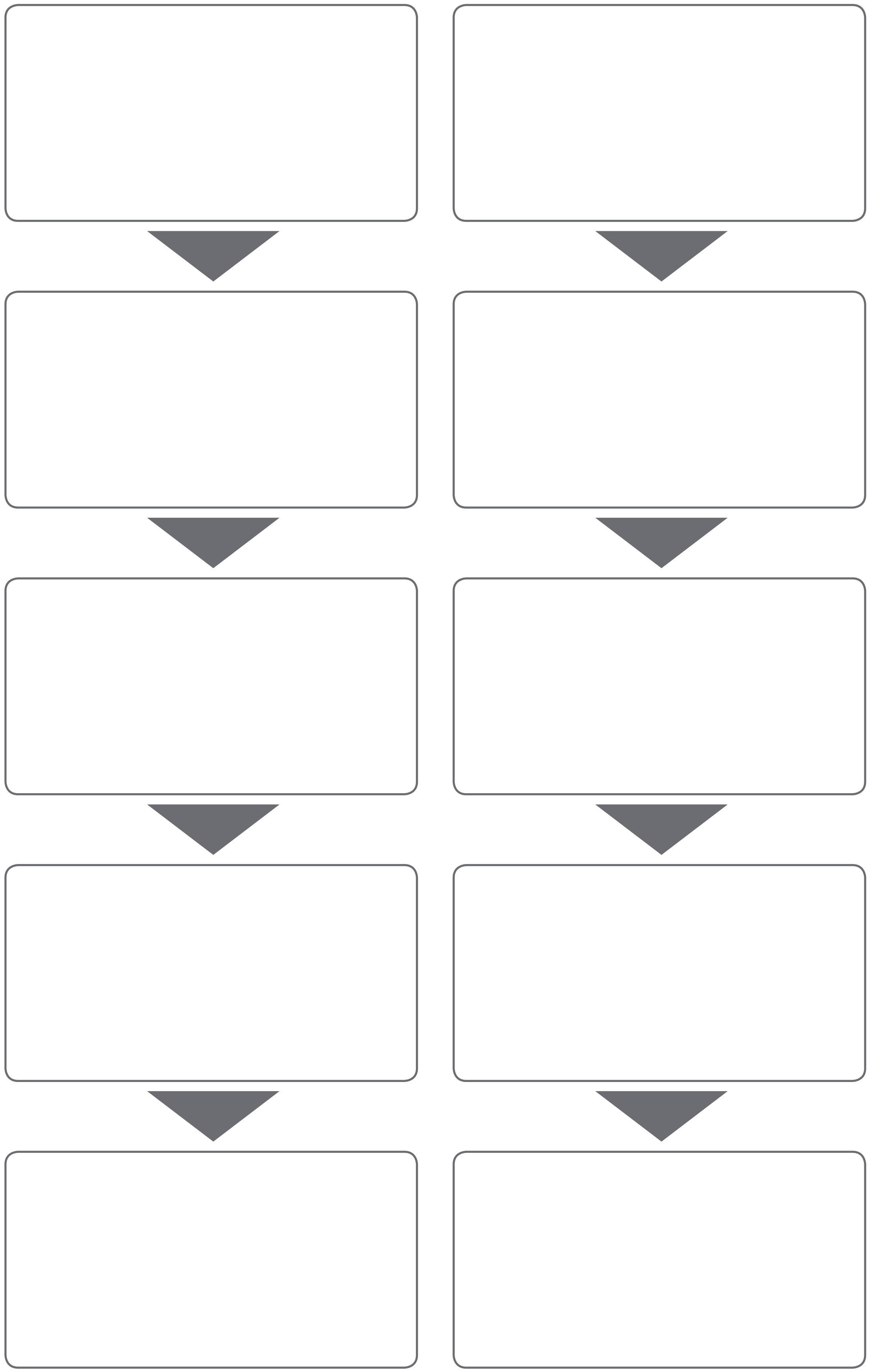
____

____

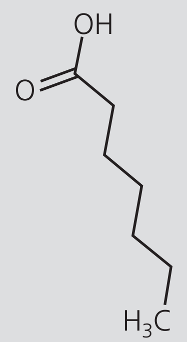
____

____

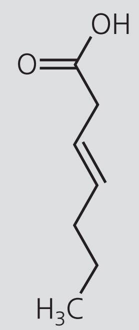
Flow Chart



Extend and Apply – Addition Reactions and Iodine Value



Saturated



Unsaturated

The fatty acid profile of canola oil shows that it is predominantly made up of 3 types of fatty acids: oleic, linoleic and linolenic acid. These three acids are called unsaturated because within their chemical structure double bonds exist between the carbons. Oleic acid is called a monounsaturated fatty acid because it has one double bond in its structure, while linoleic and linolenic acid are called polyunsaturated fatty acids because they have two or more double bonds. Saturated fatty acids have no double bonds: the carbons in the structure are "saturated" with hydrogen molecules.

The number and position of double bonds in the various types of fatty acids affects the physical properties of molecules and therefore the physical properties of biofuel. The Iodine Number or Iodine Value is a common method used to measure the stability of biofuels. Iodine undergoes an addition reaction with the double bonds found in the biofuel; a higher number of double bonds results in a higher number of iodine molecules being added to the molecule.

EXPLORE

Complete the following table of Addition Reactions. Assume all Addition Reactions continue until completion.

Find Information

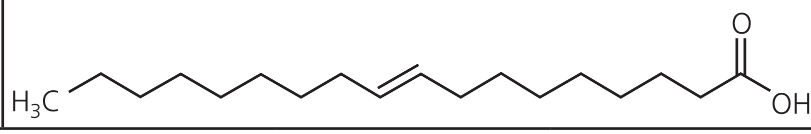
Find out more about the properties of canola oil on the Canola Council of Canada website, by accessing *Canola Oil Physical and Chemical Properties* at *www.canolacouncil.org/publication-resources/print-resources/technical-sheets/canola-oil-physical-and-chemical-properties/*.

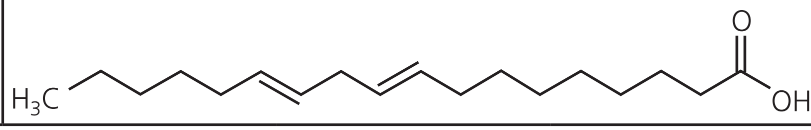
Check how iodine values are related to the chemical stability of biodiesel at *www.brevardbiodiesel.org/iv.html#glyc*.

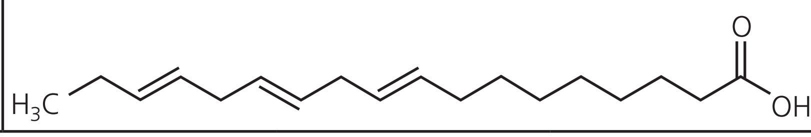
	Addition Reactions			Number of Iodine Molecules Required	Number of Iodine Atoms Required
	Reactants		Product		
Word Equation	2-pentene	Iodine			
Structures					
Word Equation	3,4-pentadiene	Iodine			
Structures					
Word Equation	Hex3ene acid	Iodine			
Structures					
Word Equation	octanoic acid	Iodine			
Structures					

EXPLORE

Consider the physical properties of the three fatty acids below. Use these physical properties to answer the questions that follow.

Common Name:	Oleic acid	**Molecular Mass:**	282.46 g/mol
Chemical Name:	9-octadecenoic acid	**Melting Point:**	13.00 °C
Chemical Formula:	$C_{18}H_{34}0_2$	**Boiling Point:**	360.00 °C
Chemical Structure:			

Common Name:	Linoleic acid	**Molecular Mass:**	280.45 g/mol
Chemical Name:	9,12-octadecadienoic acid	**Melting Point:**	-5.00 °C
Chemical Formula:	$C_{18}H_{32}0_2$	**Boiling Point:**	229.00 °C
Chemical Structure:			

Common Name:	Linolenic acid	**Molecular Mass:**	280.45 g/mol
Chemical Name:	9,12,15-octadecatrienoic acid	**Melting Point:**	-5.00 °C
Chemical Formula:	$C_{18}H_{30}0_2$	**Boiling Point:**	229.00 °C
Chemical Structure:			

1. Use structural diagrams to illustrate the complete reactions of the substances identified below.

   a. Oleic acid and iodine

   b. Linoleic acid and iodine

   c. Linolenic acid and iodine

Consider this example. How does it apply?

If you begin with 100 grams of oleic acid, how many grams of iodine will react with it?

$$n_{\text{oleic acid}} = \frac{m_{\text{Oleic acid}}}{M_{\text{Oleic acid}}}$$

$$n_{\text{oleic acid}} = \frac{100.00\ \text{g}}{282.45\ \frac{\text{g}}{\text{mol}}}$$

$$n_{\text{oleic acid}} = 0.35\ \text{mol}_{\text{oleic acid}}$$

$$1\ \text{molecule}\ (I_2)\ \text{reacts} = 1\ \text{molecule of oleic acid}$$

$$1:1\ \text{ratio}$$

$$n_{\text{oleic acid}} = n_{I_2}$$

$$0.35\ \text{mol}_{\text{oleic acid}} = 0.35\ \text{mol}_{I_2}$$

$$n_{I_2} = \frac{m_{I_2}}{M_{I_2}}$$

$$0.35\ \text{mol}_{I_2} = \frac{m_{I_2}}{507.6\ \frac{\text{g}}{\text{mol}}}$$

$$m_{I_2} = 0.35\ \text{mol}_{I_2} \times 507.6\ \frac{\text{g}}{\text{mol}}$$

$$m_{I_2} = 177.66\ \text{g}$$

177.6 grams of iodine reacts with 100 grams of oleic acid.

2. If you begin with 100 grams of linoleic acid, how many grams of iodine will react with it?

3. If you begin with 100 grams of linolenic acid how many grams of iodine will react with it?

EXPLORE

The Iodine Value of a compound is based on the number of double bonds present in the molecules and it can be calculated using the following equation:

$$\text{I.V.} = 100 \times \frac{M_{I_2} \times \text{db}}{M_{\text{f.a.}}}$$

IV = iodine value

M_{I_2} = molecular mass of iodine molecule

db = double bond

$M_{\text{f.a.}}$ = molecular mass of the fatty acid

Source: Gerhard Knothe. *Structure Indices in FA Chemistry. How Relevant Is the Iodine Value.*

4. Using the information provided, solve for the Iodine Value for:
   a. Oleic acid
   b. Linoleic acid
   c. Linolenic acid

5. Describe how your calculated iodine values relate to the melting points of the three fatty acids.

6. Infer how the calculated iodine values relate to the stability of the fatty acids.

7. Infer how the number of double bonds in the fatty acid molecules relates to the stability of structure.

LESSON SEQUENCE TWO: PRO OR CON?

Overview

In Lesson Sequence Two, students investigate pros and cons related to the use of alternative energy sources, with a focus on biofuels. They identify benefits and drawbacks from different perspectives – scientific research, public opinion and government policy – as well as the potential impact of increased use of biofuels for quality of life and the environment.

Rationale

Students should understand background, research and opinions that underlie decisions about the use of biofuels and their application to the issue of environmental and economic sustainability.

Presenting students with "I can…" statements can help focus their learning and provide a context for assessment with this lesson sequence's activities.

Inquiry

To what extent should biodiesel replace or support current production of traditional diesel fuels?

"I CAN"

Lesson Sequence Two encourages students to demonstrate their learning by developing understandings such as the following:

- ***I can** assess different and conflicting perspectives and opinions on issues involving biofuel production and consumption.*
- ***I can** identify and interpret pros and cons related to biodiesel production and consumption.*
- ***I can** apply understandings of chemical properties and processes in order to analyze and evaluate information on the future of biofuels.*

Key Concepts

Alternative energy sources | *Biodiesel blends* | *Byproducts* | *Flash point* | *Fossil fuels* | *Fuel cells* | *Renewable*

Preparation

Suggested Time: 3 to 4 80-minute class periods

The following handouts, materials and resources are used in this lesson sequence:

- Handouts
  - o Briefing Notes 2A: Pro or Con?
  - o Student Resource 2B: Research Tools
  - o Student Resource 2C: Concept Cards
  - Student Resource 2D: Extend and Apply – Biofuels vs. Fossil Fuels
- Index cards
- Internet access and interactive whiteboard to display and share website links

__Chemistry 20__ and __ICT__ outcomes for Lesson Sequence Two are listed in full on pages 2 and 3.

Inquiry

Pro or Con?

To what extent should biodiesel replace or support current production of traditional diesel fuels?

***Attitude Outcomes**

that support the responsible acquisition and application of knowledge related to science and technology are also developed and supported by this resource.

Science, Technology & Society Outcomes

- **20–A2.1sts**
- **20–A2.2sts**
- **20–A2.3sts**
- **20–D1.1sts**
- **30–C2.4k**

Skill Outcomes

- **20–A2.4s**
- **20–A2.2s (2)**
- **20–A2.3s**
- **20–C2.3s (1)**
- **20–D2.2s (1)**

ICT Outcomes

C.1 Students will access, use and communicate information from a variety of technologies.

- **ICT–C1 4.1**
- **ICT–C1 4.2**
- **ICT–C1 4.3**
- **ICT–C1 4.4**

C.2 Students will seek alternative viewpoints, using information technologies.

- **ICT–C2 4.1**
- **ICT–C2 4.2**

C.3 Students will critically assess information accessed through the use of a variety of technologies.

- **ICT–C3 4.1**
- **ICT–C3 4.2**

C.6 Students will use technology to investigate and/or solve problems.

- **ICT–C6 4.5**

Inquiry

Pro or Con?

To what extent should biodiesel replace or support current production of traditional diesel fuels?

__Chemistry 30__ and __ICT__ learning outcomes for Lesson Sequence Two are listed in full on pages 4 and 5.

***Attitude Outcomes**

that support the responsible acquisition and application of knowledge related to science and technology are also developed and supported by this resource.

Knowledge Outcomes

- **30–C2.4k**

Science, Technology & Society Outcomes

- **30–A2.1sts**
- **30–A2.2sts**
- **30–A2.3sts**
- **30–C1.1sts**
- **30–C2.3sts**

Skill Outcomes

- **30–A2.2s; 30–C1.2s; 30–C2.2s**
- **30–A2.4s; 30–C1.4s; 30–C2.4s**

ICT Outcomes

C.1 Students will access, use and communicate information from a variety of technologies.

- **ICT–C1 4.1**
- **ICT–C1 4.2**
- **ICT–C1 4.3**
- **ICT–C1 4.4**

C.2 Students will seek alternative viewpoints, using information technologies.

- **ICT–C2 4.1**
- **ICT–C2 4.2**

C.3 Students will critically assess information accessed through the use of a variety of technologies.

- **ICT–C3 4.1**
- **ICT–C3 4.2**

C.6 Students will use technology to investigate and/or solve problems.

- **ICT–C6 4.5**

Lesson Sequence Two Teaching and Learning Strategies

To what extent should biodiesel replace or support current production of traditional diesel fuels?

Introductory Activity

What are the implications of biodiesel production and consumption? In this activity, students explore and discuss their perceptions and opinions regarding alternative energy sources.

Instructional Strategy: Perspectives Poster Carousel

A carousel allows students to explore and share perspectives with other students or groups in the class. Each poster is prepared with a statement. Groups rotate through the posters at timed intervals and record their comments, opinions, experiences and perspectives on the poster paper. The carousel strategy encourages students to develop communication skills and express opinions and perspectives in a small group setting instead of in front of the entire class.

PROCESS

1. Ask students to review what they have learned about biofuels from Lesson Sequence One. Introduce the inquiry question to students: To what extent should biodiesel replace or support current production of traditional fuels? Ask students to list other alternative energy sources, such as electric, solar, nuclear, hydroelectric, wind and renewable fuel cells. Discuss students' opinions and what they know about their potential use.

2. Create posters, each with a statement such as the following, and post around the classroom. Have students work with a small group and use a carousel format to respond to each statement. Record research questions and facts, opinions and perspectives that could support or oppose each statement.

   Alternative energy sources can effectively replace fossil fuels.

   Alternative energy development creates jobs and stimulates the economy.

   Biofuels are safer than fossil fuels for humans and the environment.

   Biofuel development should be subsidized by the government.

   Biofuel production is a major cause of an increasing world food crisis.

3. Invite students to discuss what types of research – scientific, environmental, political, economic – would support the perspectives and opinions they recorded about each statement.

FIND INFORMATION

ProCon.org provides issue-based sites on a number of research topics, and provides pro and con research support and evidence. Links to issue questions can be found at http://alternativeenergy.procon.org/.

Ask students to identify individuals or groups who have differing perspectives on the issues and stances related to increased use of alternative fuels, such as biofuels. Encourage students to consider individuals or groups such as:

- Scientists, including chemists and researchers
- Farmers and canola production organizations or oil and gas producers
- Environmentalists
- Policy makers, including government
- Health practitioners
- Economists.

Discuss how each individual or group might view the opinions and perspectives represented on the posters. Are these perspectives included in the initial responses on the posters? Revisit the posters and discuss how these individuals or groups could respond to each of the statements.

Briefing Notes Activity

Students read and discuss the briefing notes with a small group. They research the pros and cons involved in biofuel production and consumption, including its link to the issue of sustainability.

Instructional Strategy: Pros and Cons Horseshoe Debate

Research and inquiry processes that are centered on the identification, analysis and synthesis of pros and cons around an issue encourage students to consider how scientific research, public perspectives and government policy influence decision making.

A horseshoe debate is an informal debating strategy that encourages students to research multiple positions and perspectives, analyze evidence that supports alternatives, and present opinions and evidence. In a horseshoe debate, desks are arranged in an open semi-circle, or a horseshoe shape. Students on one half of the semi-circle are assigned the task of presenting a prepared statement and the supporting evidence on one side of the issue. Students in the other half take the opposing position. Students can be asked to present a statement that represents an assigned role, including a summary of supporting evidence and research. Once students share their positions and evidence, the floor is opened to all students for questions and challenges. Students can be assessed on both their research and presentation, as well as on their participation in the question and challenge component of the debate.

DIFFERENTIATE

Provide students with the option of choosing the affirmative or negative side as well as selecting those who will take on roles and be responsible for presenting the perspectives of that role.

A small group of two or three students may also be assigned the role of judges and asked to monitor and assess the debate. If some students are assigned the role of judges, have them create five questions for each side, ensuring that each perspective is addressed by their questions. Structure the debate so that the judges have the opportunity to ask their questions.

PROCESS

1. Provide each student with a copy of the **Briefing Notes 2A: Pro or Con?** Work with students to discuss or respond in writing to the *Predict* questions at the beginning of the handout.

2. Have students work with a small group to explore the introductory discussion on pros and cons related to biodiesel production and consumption. Then have them research additional information related to the economic, political, consumer and environmental impact of biodiesel, using the internet sources as a starting point, but consulting textbook or other classroom, library or media sources.

DIFFERENTIATE

Students can be provided with a number of choices or options as they share their research.

- *Students can present their information to the whole class and be interviewed by classmates.*
- *Students can be regrouped, with a representative from each research group in each presentation group. Students then individually present their groups' findings to a small group.*
- *Groups can be paired and asked to present to each other.*

3. Suggest that students use index cards to gather and record their research. Then, organize the research cards to construct a pros and cons mind map or research chart. Provide groups with **Student Resource 2B: Research Tools** and have them select the visual organizers that work best for them.

4. Provide an opportunity for students to share the perspectives they have explored through their research.

5. Ask students to revisit the critical issue question they started with: *To what extent would increased production and use of biofuels make a difference to quality of life?* Ask students to share perspectives on what they have learned and how their opinions may have been strengthened or changed.

30

Introduce the following debate question to students: *Should biofuel research and development be supported with the end goal of replacing fossil fuel energy sources?* Discuss what students have learned about biodiesel as an example of an alternative energy source that could replace traditional diesel fuels. Identify initial perspectives that would contribute to the affirmative and negative sides of the debate.

Organize students into two large groups. Group One will research the affirmative side of the debate while Group Two will research the negative side of the debate.

Provide students with **Student Resource 2D: Biofuels vs. Fossil Fuels.** Have groups negotiate and assign the six roles identified on the student resource. Ensure that the other group members without specific roles complete the poster assignment described on the student resource.

Provide students with one or two class periods to complete their research or posters and with one class period in which to conduct the horseshoe debate. Monitor the time during the debate to ensure that those students who do not take on a role have the opportunity to ask questions and present challenges to the opposing side. Ask students to take notes during the debate, using the chart provided in the student resource.

After the debate, have students assess the perspectives and arguments provided. Discuss which arguments were most persuasive.

Closing Activity

Students brainstorm and create a word bank and use these words to construct a concept map, identifying relationships and connections between concepts and terms.

Instructional Strategy: Concept Map

Concept mapping can provide an effective strategy for reviewing concepts and encouraging students to draw relationships and identify connections between them. Concept maps can be completed individually, then shared with partners or small groups to students in order to clarify relationships, negotiate and increase understandings.

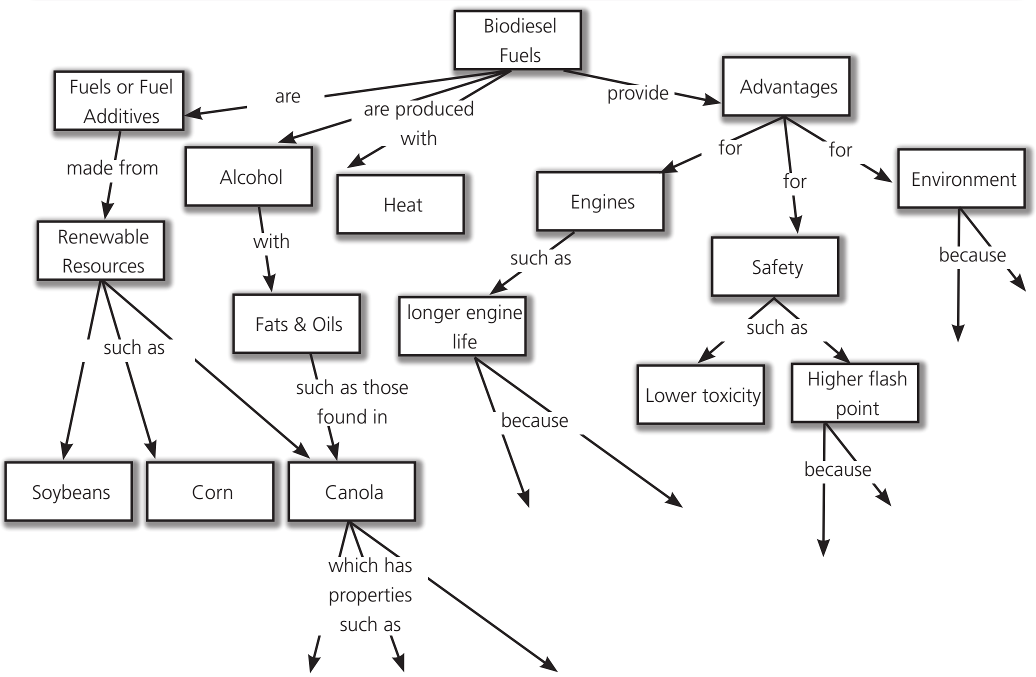
PROCESS

1. Have the class do a quick brainstorm of concepts and terms related to biodiesel – properties, production, consumption, pros and cons. Encourage students to record as many concepts and terms as they can and transfer this resulting word bank to **Student Handout 2C: Concept Cards.**

2. Ask students to work individually and use the concept cards to construct a concept map. Have them start by identifying key terms or concepts and then grouping related concepts around them. Use arrows to connect individual concepts or groups of concepts together.

3. Encourage students to discuss and justify the groupings they create in their concept maps. It is important that students understand that concepts can be grouped in different ways, depending on their rationale and perspectives.

Sample Concept Map on Biodiesel



Have students apply what they have learned about biofuels as an alternative energy source by creating a concept map that focuses on differing and diverse perspectives. Encourage students to consider the arguments presented in the debate and build their concept maps around those arguments that they personally find most compelling.

Extension Activity

Students work individually to create a futures wheel to predict the effects and implications of increasing or decreasing use of biofuels and alternative energy sources.

Instructional Strategy: Futures Wheel

Visual organizers provide an opportunity for students to synthesize their research and use it to make predictions based on evidence and facts. A "futures" wheel chart can be used to develop a conclusion and base a prediction on evidence gathered through research. The prediction can be placed in the centre of the wheel, with evidence that supports the viability of the prediction placed in the spokes of the wheel.

PROCESS

1. Invite students to revisit the predictions they made regarding the future of biotechnology in the *Introductory Activity* of this lesson. Provide each student with the Wheel Chart from **Student Resource 2B: Research Tools.**

2. Have each student create a "futures" wheel chart that describes a prediction about the future development and implications of biofuels, biodiesel and alternative energy sources and technologies.

3. Encourage students to use evidence found and shared by classmates to record reasons for the prediction in the spokes of the futures wheel.

Pro or Con?

Predict

What do you think the major benefit of canola-based biodiesel is? What might be the major drawback?

____

____

What would you predict for the future use of biofuels in Canada? In other areas of the world? Why?

____

____

Biofuel technology has been around as long as the combustion engine. However, concerns about fuel security and climate change as well as increasing concerns over support for rural economies have stimulated research and development into alternative fuels and biodiesel. The discussion about alternative fuels and energy sources has also affected public and government policy.

What are the pros and cons of biofuels and, more specifically, biodiesel? Most proponents of increasing the use of biodiesel cite environmental and economic benefits. They also mention the fact that biodiesel can be used in existing diesel engines and that it is a renewable resource. Those people who have concerns about biofuels mention the cost and the lack of availability on the scale that is needed to make a difference to the environment and economies.

FIND INFORMATION

Watch a video: What is Canola Oil? *at www.canolainfo.org/canola/index.php.*

A series of videos on biodiesel use and production is available on the BioFleet website in Historical Archive Materials, under the Videos *section at www.biofleet.net/resources/archive.*

Analyze promotional messaging and advertising about biodiesel by watching the videos available on the National Biodiesel Board's website at www.biodiesel.org/news/video-library. How do these videos reflect the biases of this American organization?

Regardless of the perspective that is brought to the debate over alternative fuels, many discussions consider the following effects of their production and consumption:

- Economic implications
- Impact on the environment
- Political policies
- Value to producers and consumers.

As you read the discussions and explore the sources that follow, consider what they present regarding the pros and cons of biodiesel as a future alternative source of energy.

Canola biodiesel: A perspective from canola producers

How is canola biodiesel made?
Biodiesel is produced using canola oil, which comes from canola seed, through a refinery process called transesterification. This process is a reaction of the oil with an alcohol to remove the glycerine, which is a byproduct of biodiesel production. Pure, 100% biodiesel – called B100 – can be blended in any proportion with petroleum diesel. The most common blends are 2% (B2), 5% (B5) and 20% (B20).

What about the quality of canola biodiesel?
Canola has low saturated fat content, which gives it superior cold flow properties, perfect for Canadian winters.

How do energy and emissions of canola biodiesel compare to petroleum diesel?
Engines that currently run on petroleum diesel – heavy equipment, long-haul trucks, farm machinery, municipal fleets and generators – require no modification to run on biodiesel. However, they would produce considerably fewer greenhouse gas (GHG) emissions using biodiesel compared to petroleum diesel.

The Canadian government has committed to addressing climate change by working to reduce GHG emissions. The use of canola as a feedstock in biodiesel reduces lifecycle greenhouse gas emissions by 90 percent compared to fossil diesel. This means that switching Canada's diesel engines to a two percent biodiesel blend will reduce GHG emissions by 1.8 million tonnes, equal to taking 300 000 cars off the road. A 5 percent biodiesel inclusion rate would be equal to removing 750 000 cars.

Growing canola sequesters carbon in the soil. Reduced tillage practices that are commonly used in canola production also mean less carbon is released.

How much energy does it take to produce canola biodiesel?
One litre of petroleum diesel is needed to produce 4 litres of diesel or 2.5 litres of canola biodiesel. That includes all phases of crop production, biodiesel manufacturing and transportation.

However, canola, unlike petroleum, is a renewable rather than non-renewable resource. It is grown in abundance in a sustainable manner across the prairies, with additional acres in Ontario. As more farmers begin to use biodiesel, the energy balance for canola biodiesel only improves.

Is there enough canola to produce biodiesel?
The introduction of new canola hybrids and biotech traits, along with improved agricultural practices has allowed Canadian farmers to improve canola yields over the past 15 years to meet both food and fuel demands. According to Statistics Canada, canola yields have risen 50 percent from an average of 21.8 bushels per acre in 1995 to 32.5 bushels per acre in 2010.

Continued yield improvements mean that Canadian farmers are already growing more than enough canola to fill the demand for both food and fuel. The federal government's two percent biodiesel mandate would require about one million tonnes (MT) of canola seed annually. Historically, food demand has left enough **carryover** (ending stocks) of canola seed to fill this biofuel demand.

To ensure that there is sufficient canola to meet human food and fuel needs, the canola industry has set a production target of 15 million tonnes by the year 2015.

Source: *Canola: A Sustainable Source for Food and Fuel:* Canola Council of Canada. www.canolacouncil.org/media/509083/1foodandfuel.pdf

Biodiesel – Key Issues: Canadian Renewable Fuels Association (2010). www.greenfuels.org/uploads/documents/biodiesel-fact-sheets.pdf

Is canola biodiesel good for Canadian farmers and the economy?
The federal government's current mandate of a two percent inclusion standard for biofuel in all diesel fuel sold in Canada creates a sustainable domestic market for excess canola seed, improves farm revenues and helps generate jobs and economic activity in value-added industries such as crushing and processing.

As of 2010, Canada exported 85 percent of the canola it produced either as seed, or oil and meal. Japan is Canada's largest seed customer and the US is the largest oil customer. The federal renewable fuel standard provides fundamental, long-term support for Canadian farmers by creating inelastic demand. Canola is vulnerable to borders shutting because of tariffs and non-tariff trade barriers. "Made-in-Canada" canola biodiesel will stabilize demand and help increase the value-added industry that is already expanding in Canada in anticipation of increased use of canola in North America.

Economic analysis shows that every $1 invested in biodiesel infrastructure returns $2 of economic activity in construction and supporting industries. Also, the meal produced from canola crushing is a high protein livestock feed that can replace more expensive imported protein meal in dairy and hog rations.

More about byproducts

Although the only direct byproduct of biodiesel is glycerine, there are a number of products that can be made from this byproduct. Glycerine can be used as a degreaser and hand soap. Purified glycerine can also be used in cosmetic products. Some researchers are looking at ways to produce high value chemicals like succinate and formate with fermentation technologies.

What are the risks?

Is there a negative side to considering the use of biodiesel? Some would say of course – there is no such thing as a perfect fuel. Biodiesel is not always readily available in different places. However, availability is increasing and there is a lot of activity with home-produced biodiesel.

Biodiesel has a higher gel point than petroleum based fuels. B100 biodiesel, which is 100% pure, can start to gel at approximately -17 ^{o}C. Blending biodiesel with other additives, such as petroleum-based diesel and kerosene, can decrease its gel point.

One emission that increases with biodiesel is NOx, which contributes to smog. Some say that this increased emission is compensated for by the reduction in other types of emissions.

What about other alternative energy sources?

There is a wealth of information on the pros and cons of other alternative energy sources, such as solar, wind and hydrogen fuel cells. How do these other potential energy sources affect biodiesel use? Many biodiesel producers state that biodiesel is the most cost effective energy alternative and the easiest to implement, as biodiesel can be used in existing diesel engines with little or no modification. They assert that biodiesel is safe to handle and transport because it is as biodegradable as sugar, one-tenth as toxic table salt, and has a flash point of about 150^{o}C compared to petroleum diesel fuel, which has a flash point of about 70^{o}C. The flash point of a fuel is the temperature at which the fuel will ignite when exposed to a spark or a flame. Biodiesel also has a wide range of applications compared to wind or solar energy. Critics say that biodiesel is still more expensive to produce than petroleum-based diesel fuel and is less efficient.

EXPLORE

Find out more about the claims made about the pros and cons of biodiesel. Collect your research on index cards, ensuring that you cite sources.

Organize your index cards to construct in a pros and cons chart or mind map. Consider how biodiesel production and consumption affects each of the following:

- **The environment**
- **Farmers and canola production organizations**
- **Economic conditions and production**
- **Political factors (think about Canada's use of foreign sources of energy)**
- **Individual consumers.**

Consider the following questions as you organize your cards to construct the pros and cons chart or mind map:

- What are the different perspectives and who brings these to the discussion on biodiesel production and consumption? How will these individuals or groups affect the way you organize your research?

- Make sure that you consider the reliability of the sources you consult. Is there additional information that you need to research in order to validate the sources you have used?
- Should this information be presented as fact or opinion? How do fact and opinion affect the way you organize your research?

Find Information

The Canola Council of Canada provides information on the benefits and policies that influence canola based biodiesel production in Canada. Consider the arguments that they present on the benefits of a significant investment in a Canadian biodiesel industry. Each of the following factsheets can be accessed at *www.canolacouncil.org/canola-biodiesel/reports-and-news/fact-sheets/*.

1. Canola, a sustainable source for food and fuel
2. A canola-based biodiesel industry would benefit Canadians
3. Canola-based biodiesel can help the environment
4. Canola is a high quality feedstock for biodiesel production
5. Biodiesel allows canola growers to participate in the value chain
6. A "made in Canada" biodiesel industry requires policy change
7. The impact of a canola-based biodiesel industry in Canada
8. Clean-burning biodiesel is used across the European Union

Natural Resources Canada provides detailed information about alternative energy sources, government programs and links to resources on their *Alternative Fuels* website at *http://oee.nrcan.gc.ca/transportation/alternative-fuels/780*.

Biodiesel, an American website, provides fact sheets and brochures about biodiesel, sustainability and future projections at *www.biodiesel.org/what-is-biodiesel/biodiesel-fact-sheets*.

A detailed overview of the renewable fuels industry is provided by the Canadian Renewable Fuels Association in *Growing Beyond Oil: Delivering our Energy Future*, available at *www.greenfuels.org/uploads/documents/crfareportcardenglish2010final.pdf*. A summary of key issues around Biodiesel is available at *www.greenfuels.org/uploads/documents/biodiesel-fact-sheets.pdf*.

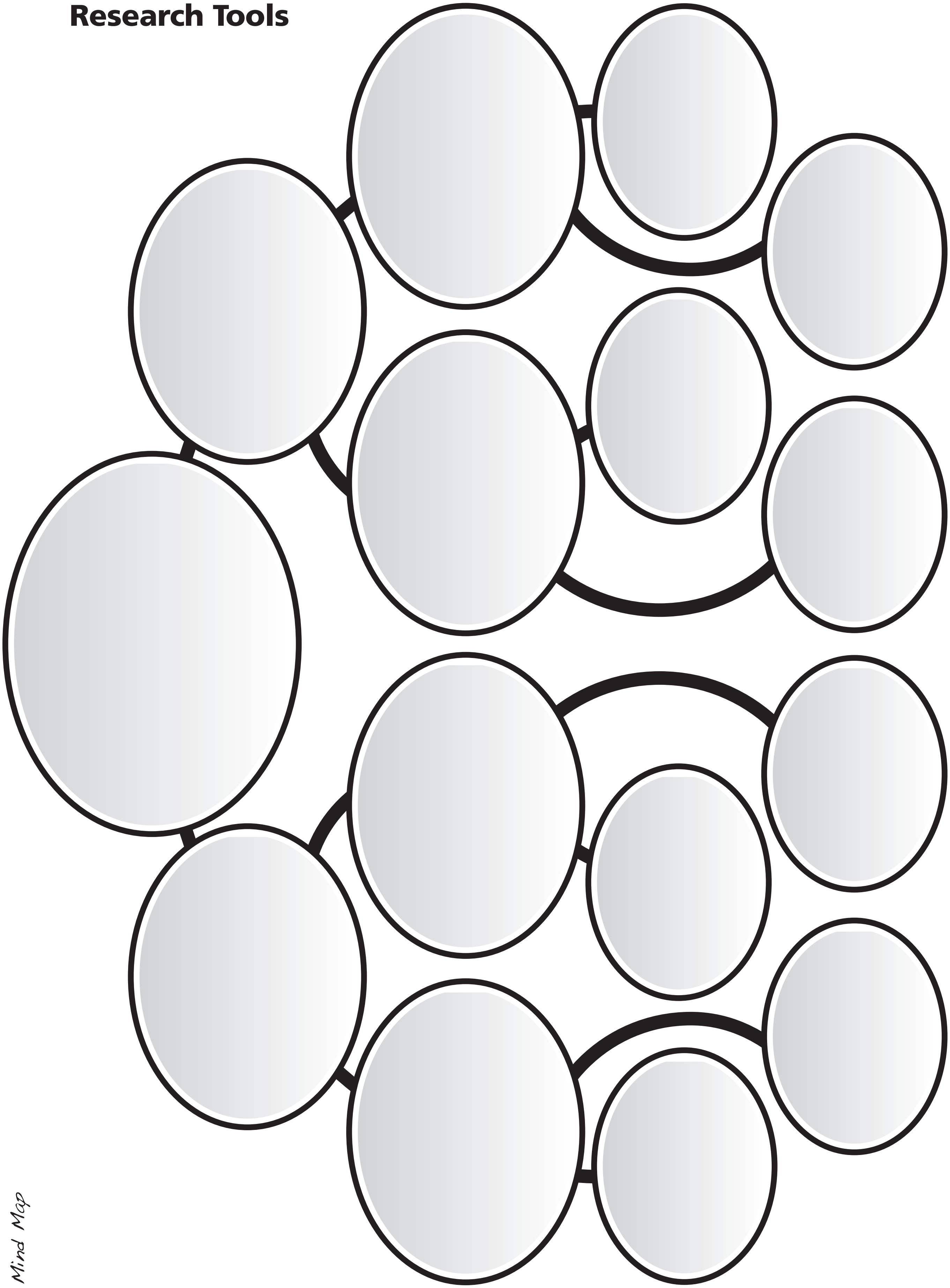
The *Bioenergy Canada* magazine provides links to their most current publications, which include articles on bioenergy, biofuels, political issues and public policy at *www.canbio.ca/article/bioenergy-magazine-125.asp*.

Perspectives on the economic impact of canola prices and biodiesel production can be found on the Top Crop Manager website at *www.agannex.com/agrobiomass/biofuels*.

The Union of Concerned Scientists website provides some perspectives on the pros and cons of biodiesel at *www.ucsusa.org/clean_vehicles/technologies_and_fuels/biofuels/biodiesel-basics.html*.

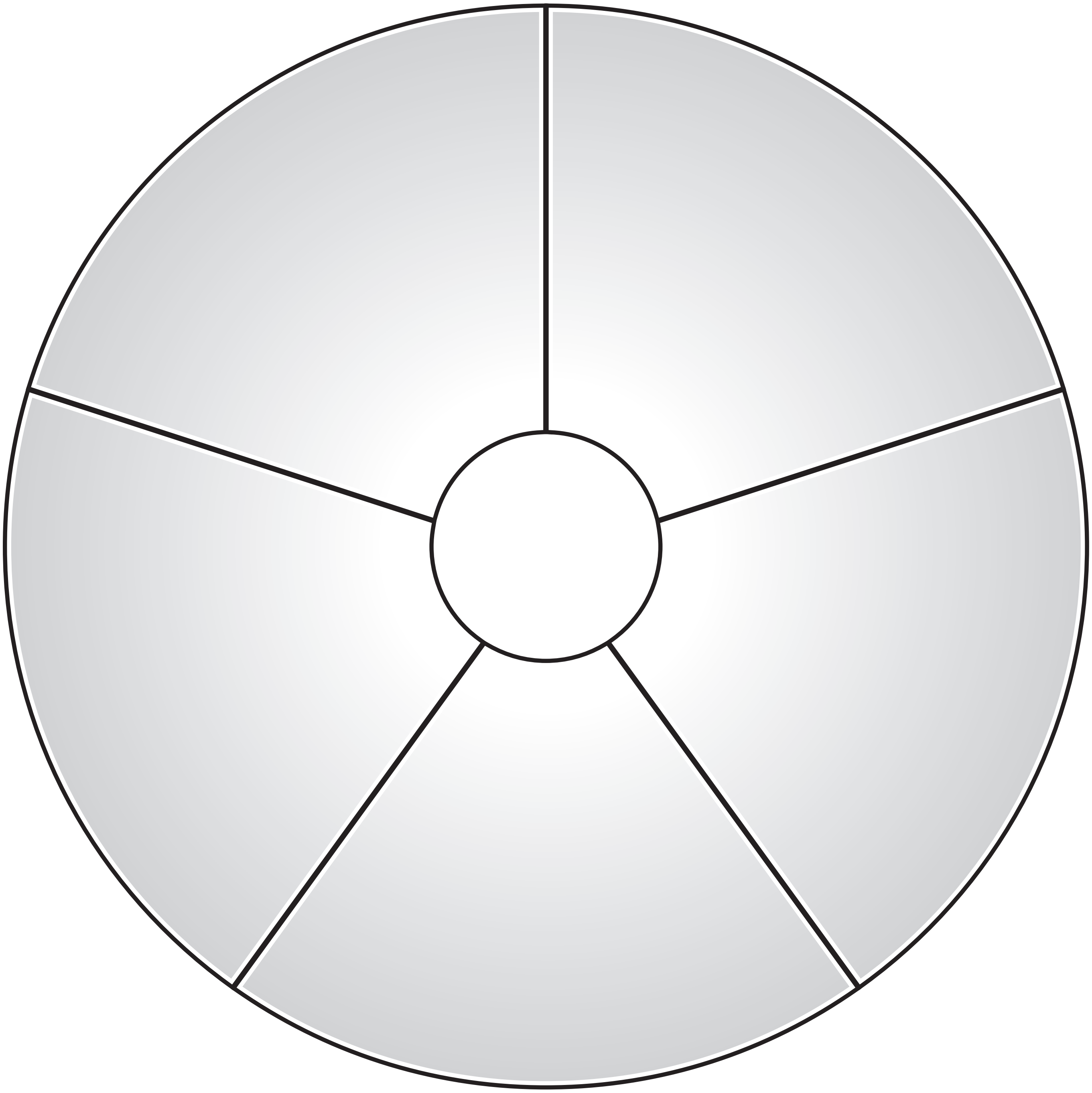
ProCon.org provides an overview of the *Top 10 Pros and Cons* on the issue of alternative energy at *http://alternativeenergy.procon.org/view.resource.php?resourceID=001792*. Additional links to more information are provided at *http://alternativeenergy.procon.org/*. Are these American perspectives different from Canadian perspectives? In what ways?

Research Tools



T-Chart

Wheel Chart



Concept Cards

Extend and Apply – Biofuels vs. Fossil Fuels

Should biofuel research and development be supported with the end goal of replacing fossil fuel energy sources?

Prepare for a debate on this question with your debate group. Use one of the following task boxes to organize and guide your role in the debate. Use the chart at the end of this resource to take notes and record your thoughts and ideas as the debate is presented.

Yes!

Assign the following roles to six group members.

The Chemist

Explain the chemical processes involved in the production of biofuels. Your explanation must include but is not limited to the following key terms: *esterification, fatty acids, methanol* and *biodiesel.*

The Farmer and Canola Producers Organization

Defend the production and use of canola biodiesel through the farmer's perspective. Consider how organizations associated with the Canadian canola industry provide research and support for increased production of biofuels.

The Environmentalist

Defend the use of biofuels through an environmental perspective.

The Policy Maker

Defend the use of biofuels through a political perspective. Consider what government is and should be doing to promote and support the development of biofuels.

The Health Practitioner

Defend the use of biofuels through a health perspective. Find out what impact biofuels would have on health and well being for people.

The Economist

Defend the use of biofuels through an economic perspective. Consider the costs and benefits associated with researching, supporting and developing biofuels to replace traditional fossil fuels.

The Closer

Provide a summation of the arguments presented that support the use of biofuels. Ensure that you consult with all of your group members to prepare your summary.

No!

Assign the following roles to six group members.

The Chemist

Explain the chemical processes involved in refining conventional fossil fuels. Your explanation must include but is not limited to the following key terms: *combustion hydrocracking, catalytic reforming.*

The Oil and Gas Producer

Defend the use of fossil fuels and production methods by considering economic benefits, efficiency and measures that producers are putting into place to increase environmental protections. Consider the costs and effects of replacing current dependence on fossil fuels with alternative energy sources, such as biofuels.

The Environmentalist

Defend the use of fossil fuels through an environmental perspective. Consider whether there are risks and limitations associated with biofuels as compared to fossil fuels.

The Policy Maker

Defend the use of fossil fuels through a political perspective. Consider what government can do to support the sustainable use of fossil fuels as well as the challenges involved in establishing policies regarding biofuels.

The Health Practitioner

Defend the use of fossil fuels through a health perspective. Consider current policies for fossil fuel production that protect health and well being as well as limitations with the use of biofuels.

The Economist

Defend the use of fossil fuels through an economic perspective. Consider the costs and benefits associated with researching, supporting and developing fossil fuels compared to those associated with biofuels.

The Closer

Provide a summation of the arguments presented that support the use of fossil fuels. Ensure that you consult with all of your group members to prepare your summary.

Poster Assignment

Create a poster that supports your group's position for the debate. Your poster must include the following:

- The chemical process of producing biofuels *(transesterification)* or the chemical process of refining conventional fossil fuels *(hydrocracking* or *catalytic reforming).*
- An environmental, political, health or economic perspective for the use of this type of fuel.

Should biofuel research and development be supported with the end goal of replacing fossil fuel energy sources?

Role	Notes from the Argument for Biofuels	Notes from the Argument for Fossil Fuels	Most Convincing Argument
The Chemist			
The Farmer and Canola Production Organizations OR the Oil and Gas Producer			
The Environmentalist			
The Policy Maker			
The Health Practitioner			
The Economist			
The Closer			
		Most Convincing Group Overall:	