For Teachers

Should Vegetable Oil be used as a Fuel ?

Teaching Guide

This project relates to biodiesel and the process of transesterification. Neither are usual topics within a science (chemistry) curriculum. However an understanding of the process and the development of the skills in making the actual product are secondary to the educational skills of devising procedures (by the students) to measure ease of burning, viscosity, suitability of flame and calorific value. The project can also be used to consolidate learning on esters and esterification.

In total it is suggested this module will occupy 5 lessons in order to meet the education objectives put forward. The suggested breakdown is given below, noting that reaction time and separation time are lengthy and neither can be completed within a 45 minute lesson.

Learning Outcomes by Lesson

At the end of lessons 1, students are expected to be able to:

- Discuss why vegetable oils are a good fuel, but not usable as is.
- Made preparations for making bio-diesel

At the end of lesson 2, students are expected to be able to:

- Undertake the preparation of a biodiesel.
- Devise a procedure for separating out the product; operate a separating funnel.
- Devise tests to determine the suitability of biodiesel as a fuel.

At the end of lesson 3, students are expected to be able to:

- Separated out the bio-diesel
- Shown understanding of the process of trans-esterification and a comparison with tri-hydric esters

At the end of lessons 4, students are expected to be able to:

- Carry out the tests on samples of the biodiesel
- Explain the testing of the suitability of bio-diesel for use as a fuel

At the end of lessons 5, students are expected to be able to:

- Cooperate as a member of a team in a debate on the use of bio-diesel

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- Put forward a justified socio-scientific decision on whether vegetable oils should be used as a fuel

Suggested Teaching Strategy

1. To prepare a number of samples of biodiesel by one student or one group of students is obviously a time consuming process. It is recommended for this project that different groups of students work with different vegetable oils and results are compared between groups.
2. To prepare biodiesel, students utilize the instructions given in the handout. Students should test various vegetable oils. The amount of chemicals can be scaled down if necessary.
3. The initial lesson is suggested as a group discussion on what is biodiesel and can it be used as a fuel. This enables students to become familiar with the term biodiesel and its origins, differing from those of diesel made from petroleum. In this manner the teacher is able to determine the students prior knowledge in this area and their initial attitudes towards the issues being put forward.
4. Another important goal for the first lesson is to recognize that although vegetable oils burn, they are not suitable for use in the standard diesel engine because of the high viscosity. Hence there is a need to reduce viscosity, one way being to make a new substance of lower viscosity. This sets the process for the next lesson which is to make biodiesel by reduction of viscosity and one fairly simply process for this is to replace the ester groups.
5. The second lesson can begin with setting up the experimental process based on experimental procedures supplied. Once the experiment is underway, students can be asked to write a possible procedure for the separation of the biodiesel and be introduced to the use of a separation funnel. Time permitting students can also begin initial thinking on how to test the biodiesel for suitability for use.
6. The third lesson is related to the separation of the biodiesel which is a time consuming process but one requiring little student attention once it is set up. The extra time can be used to prepare for the testing of the biodiesel in the next lesson, both in terms of the conceptual understanding of suitability and in how the experimentation can be conducted.
7. Having prepared a sample of biodiesel, students are then challenged in the 4th lesson to test the biodiesel and compare it with diesel. The tests suggested are -

a) Determining Flammability,

Intended here is a simple test of how easy it is to burn the product. Putting a match to a little of the sample on a watch glass is perhaps the simplest manner in which this test can be performed.

If this does not lead to a noticeable difference between the various biodiesels or between a biodiesel and ordinary diesel, then more sophisticated tests can be devised.
[Industrially the temperature at which a biodiesel burns after ignition by an electric spark is obtained. Also measured is the flash point - the temperature at which the fuel self ignites. THESE TESTS ARE NOT SUGGESTED.]

b) Suitability of flame.

Is it possible to burn biodiesel, or ordinary diesel in the standard spirit burner ? If so, the 'sootiness' of the flame can be compared. A sooty flame indicates incomplete combustion and gives a measure of whether the fuel will be efficient and whether it leads to greater pollution of the atmosphere.

c) Viscosity (Quantity of product nay be a problem to perform this test)

Again the emphasis is on a simple test such as the time it takes a weight (ball bearing) to fall through the biodiesel for a given length.
A test tube is not really long enough but a length of wide bore glass tubing is good. Should this not be available, a 1 litre plastic bottle can be used but the quantity of oil needed is obviously much greater. Other substitutes can be used to show that something like a ball bearing will take different times to fall through the liquid is dependent on the viscosity.

d) Calorific value

The emphasis is on simple apparatus and, if necessary, students can devise ways to minimise heat losses by draughts, etc.
The suggestion is to burn a known quantity of fuel in a spirit burner and to use this to heat a small tin can containing a known quantity of water. The quantity of fuel needed to raise the temperature of the water by a standard temperature rise ($5^{o}C$) is determined and used as a measure of the calorific value. (Whether students undertake the actual calculation depend on the level if the students).

8. Students are expected to create a record of their experimental work from the preparing of biodiesel, its separation and its testing for suitability as a fuel.
9. The final lesson is a return to the debate on the issue of whether biodiesel should be used as a fuel, considered from a variety of perspectives. The lesson focuses on the use of argumentation skills and the correct scientific conceptualisation of biodiesel (especially with respect to it being a 'clean' fuel), but the lesson is expected to include input from ethical considerations (the use of foodstuff for producing the fuel), economic (cost of biodiesel), environmental considerations (use of land, etc) and other considerations.

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SUGGESTED TEACHING- LEARNING OUTLINE

STAGE	TEACHING - LEARNING APPROACH	TEACHING - LEARNING OUTLINE
1. Setting the scene	Material presented through a real life title and scenario. (1 lesson)	1. Appreciate that vegetable oils burn and cause less pollution as they are esters (containing O). 2. Realisation that vegetable oils are too viscous to use in a diesel engine as is. 3. Aware that the vegetable oil can be made less viscous by exchange of the ester groups.
2. Inquiry-based Problem Solving	Teacher guided, Student-centred material includes Problem Solving, Nature of Science and Conceptual Science Learning (and consolidation of the conceptual learning through adequate feedback - assessment). (3 lessons)	1. Making biodiesel by a trans-esterification process in a non-aqueous solvent. 2. Separation of the biodiesel by making use of a separating funnel. 3. Devise tests, which include flammability, colour of flame, calorific value and viscosity, to determine the suitability of biodiesel as a fuel. 4. Carry out tests and record outcomes
3. Socio-Scientific Decision Making	Teacher guided, Student centred material includes reasoned socio-scientific decision making (and consolidation of the conceptual learning through adequate feedback – assessment). (1 lesson)	1. Knowing the suitability of biodiesel as a fuel and taking note of the economic availability of biodiesel and the ethical question of whether edible vegetable oils should be used as a source of fuel, discuss the issue of whether vegetable oils should be used as a fuel .

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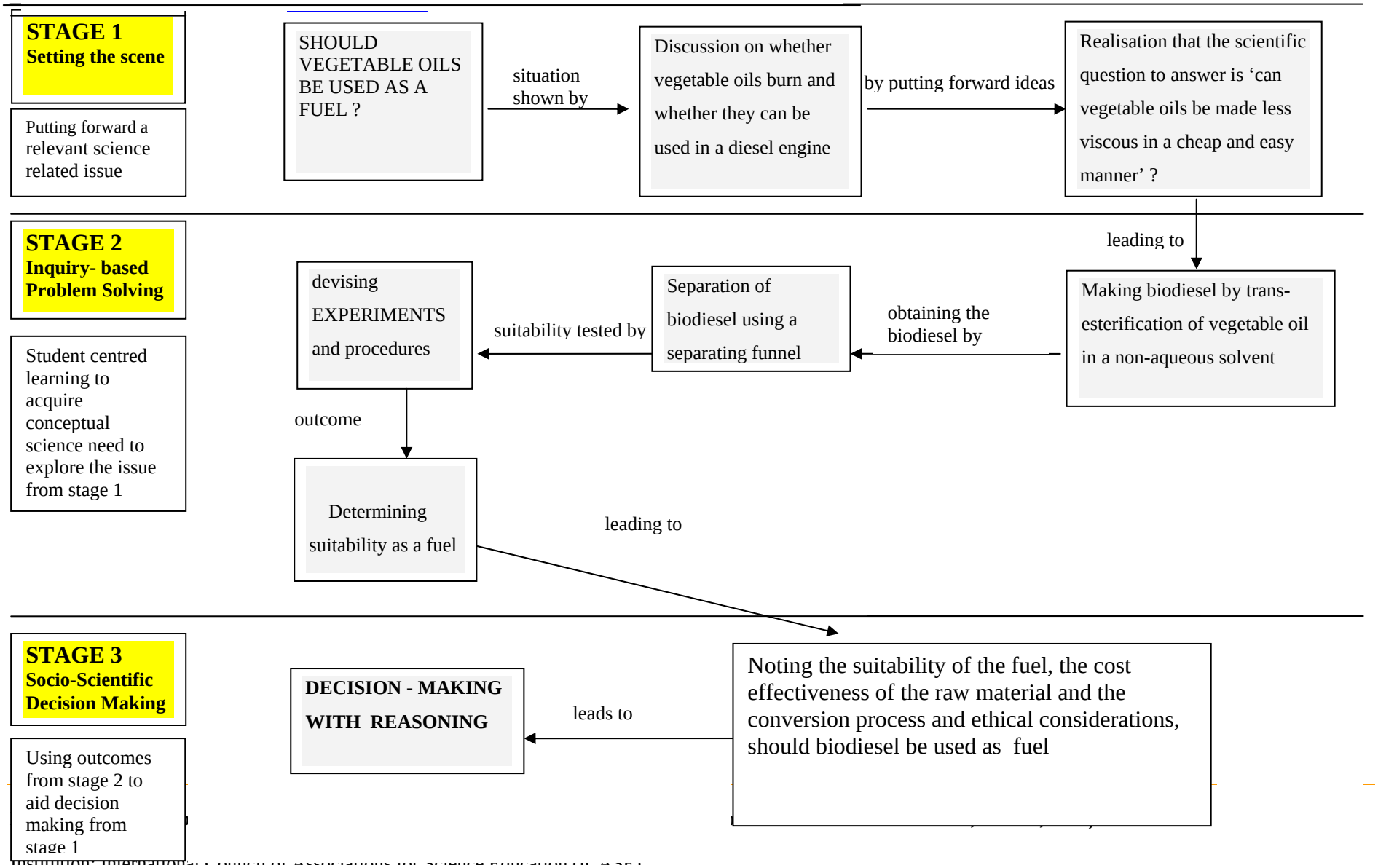
Suggested Teaching Flowchart



Achieving the objectives

* to be able to make biodiesel;

  This objective is achieved by students following the instructions given in the handout and preparing a sample of biodiesel.

* to devise procedures for testing the biodiesel;

  This challenging objective is achieved by students being called upon to devise their own tests for flammability, suitability of flame, viscosity and calorific value.

* to suggest parameters for deciding on the 'best' biodiesel;

  This is achieved by students putting forward their ideas on which biodiesel is best after they have tested a number of biodiesel fuels.

* ability to discuss the merits and demerits of using vegetable oils as fuels

  Students achieve this objective by undertaking a written discussion on the merits and demerits

* to cooperate as part of a team;

  In undertaking the production and testing of biodiesel fuels, it is expected that different groups of students will test different vegetable oils and that within groups, students will cooperate as a team in the production of the biodiesel and then its subsequent testing.

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