**Green Chemistry**

**Bio diesel and Bio petrol also study extraction process of Bio diesal**

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in the CHEMISTRY LAB during the year

Date \_\_\_\_\_\_\_\_\_\_\_\_\_.

Submitted for **CENTRAL BOARD OF SECONDRY EDUCATION**

Examination held in CHEMISTRY LAB at

**EXAMINER**

**DATE : \_\_\_\_\_\_\_\_\_\_\_**

**SEAL**

I would like to express my sincere gratitude to my chemistry mentor

**Miss.** , for her vital support, guidance and encouragement – without which this project would not have come forth. I would also like to express my gratitude to my old chemistry teacher **…………….** for his support during the making of this project.

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The Objective of this project is to study GREEN CHEMISTRY- Bio diesel and Bio petrol also study extraction process of Bio desial.

**INTRODUCTION TO GREEN CHEMISTY**

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Green chemistry is the branch of chemistry concerned with developing processes and products to reduce or eliminate hazardous substances. One of the goals of green chemistry is to prevent pollution at its source, as opposed to dealing with pollution after it has occurred.

**Principles of Green Chemistry**

**1.**

**Prevention**

It is better to prevent waste than to treat or clean up waste after it has been created.

**2.**

**Atom Economy**

Synthetic methods should be designed to maximize the incorporation of all materials used in the process into the final product.

**3.**

**Less Hazardous Chemical Syntheses**

Wherever practicable, synthetic methods should be designed to use and generate substances that possess little or no toxicity to human health and the environment.

**4.**

**Designing Safer Chemicals**

Chemical products should be designed to effect their desired function while minimizing their toxicity.

**5.**

**Safer Solvents and Auxiliaries**

The use of auxiliary substances (e.g., solvents, separation agents, etc.) should be made unnecessary wherever possible and innocuous when used.

**6.**

**Design for Energy Efficiency**

Energy requirements of chemical processes should be recognized for their environmental and economic impacts and should be minimized. If possible, synthetic methods should be conducted at ambient temperature and pressure.

**7.**

**Use of Renewable Feedstocks**

A raw material or feedstock should be renewable rather than depleting whenever technically and economically practicable.

**8.**

**Reduce Derivatives**

Unnecessary derivatization **(**use of blocking groups, protection/ deprotection,temporary modification of physical/chemical processes**)** should be minimized or avoided if possible, because such steps require additional reagents and can generate waste.

**9.**

**Catalysis**

Catalytic reagents (as selective as possible) are superior to stoichiometricreagents.

**10.**

**Design for Degradation**

Chemical products should be designed so that at the end of their function they break down into innocuous degradation products and do not persist in the environment.

**11.**

**Real-time analysis for Pollution Prevention**

Analytical methodologies need to be further developed to allow for real-time, inprocess monitoring and control prior to the formation of hazardous substances.

**12.**

**Inherently Safer Chemistry for Accident Prevention**

Substances and the form of a substance used in a chemical process should be chosen to minimize the potential for chemical accidents, including releases,explosions, and fires.

Biodiesel: using renewable resources

**Introduction**

|  |
| --- |
| Bio-diesel is an eco-friendly, alternative diesel fuel prepared from domestic renewable resources i.e. vegetable oils (edible or non- edible oil) and animal fats. These natural oils and fats are made up mainly of triglycerides. These triglycerides when rea w striking similarity to petroleum derived diesel and are called “Bio-diesel”. As India is deficient in edible oils, non-edible oil may be material of choice for producing bio diesel . For this purpose Jatropha curcas considered as most potential source for it. Bio diesel is produced by transesterification of oil obtains from the plant. |
| Jatropha Curcas has been identified for India as the most suitable Tree Borne Oilseed (TBO) for production of bio-diesel both in view of the non-edible oil available from it and its presence throughout the country. The capacity of Jatropha Curcas to rehabilitate degraded or dry lands, from which the poor mostly derive their sustenance, by improving land’s water retention capacity, makes it additionally suitable for up-gradation of land resources. Presently, in some Indian villages, farmers are extracting oil from Jatropha and after settling and decanting it they are mixing the filtered oil with diesel fuel. Although, so far the farmers have not observed any damage to their machinery, yet this remains to be tested and PCRA is working on it. The fact remains that this oil needs to be converted to bio-diesel through a chemical reaction – trans-esterification. This reaction is relatively simple and does not require any exotic material. IOC (R&D) has been using a laboratory scale plant of 100 kg/day capacity for trans-esterification; designing of larger capacity plants is in the offing. These large plants are useful for centralized production of bio-diesel. Production of bio-diesel in smaller plants of capacity e.g. 5 to 20 kg/day may also be started at decentralized level. |

Activity 1: Making biodiesel

Biodiesel is a mixture of methyl esters of fatty acids (long chain **carboxylic acids**). It has similar properties to the diesel fuel made from crude oil that is used to fuel many vehicles. It can be made easily from vegetable cooking oil that contains compounds of fatty acids. Enough fuel can be produced in this activity to burn in a later activity, although it is not pure enough to actually be used as fuel in a car or lorry. The synthesis is a simple chemical reaction that produces biodiesel and propane-1,2,3-triol (glycerol). Cooking oil is mixed with methanol and potassium hydroxide is added as a catalyst. The products separate into two layers, with the biodiesel on the top. The biodiesel is separated and washed, and is then ready for further experimentation.

**What you will need**

Eye protection

Access to a top pan balance

One 250 cm3 conical flask

Two 100 cm3 beakers

One 100 cm3 measuring cylinder

Five plastic teat pipettes

Distilled or deionised water

100 cm3 vegetable-based cooking oil

15 cm3 methanol (highly flammable, toxic by inhalation, if swallowed, and by skin absorption)

1 cm3 potassium hydroxide solution 50% (corrosive).

**Safety**

Wear eye protection.

Methanol is flammable and poisonous.

Potassium hydroxide is corrosive.

**What to do**

1. Measure 100 cm3 of vegetable oil into the 250 cm3 flask. Weigh the flask before and after to determine the mass of oil you used.
2. Carefully add 15 cm3 of methanol.
3. Slowly add 1 cm3 of 50% potassium hydroxide.
4. Stir or swirl the mixture for 10 minutes.
5. Allow the mixture to stand until it separates into two layers.
6. Carefully remove the top layer (this is impure biodiesel) using a teat pipette.
7. Wash the product by shaking it with 10 cm3 of distilled or deionised  water.
8. Allow the mixture to stand until it separates into two layers.
9. Carefully remove the top layer of biodiesel using a teat pipette.
10. Weigh the amount of biodiesel you have collected and compare it to the amount of vegetable oil you started with.

**Apparatus for testing biodiesel**

**Activity 2: Testing biodiesel**

How does biodiesel compare to other fuels? Just because we can produce a fuel from an alternative source, does that mean it is a good idea? There are many factors that go into the decision to use alternative fuels.  Ideally the physical properties of an alternative fuel should equal or exceed those of the traditional product. But how are fuels evaluated in the first place. In this activity, biodiesel and some other fuels are tested and compared for sootiness and acidity.

**What you will need**

Eye protection

Small glass funnel (approximately 7 cm diameter)

One 250 cm3 flask

Two boiling tubes

One two-hole stopper to fit the boiling tubes

Filter pump

A piece of wide bore glass tubing approximately 10 cm long with two one-hole stoppers to fit

A piece of vacuum tubing approximately 35 cm long

Two short pieces of glass tubing to fit the one-hole stoppers

5 cm glass bend to fit the two-hole stopper

90o glass bend to fit the two-hole stopper (one leg to extend to bottom of flask)

Two stands and clamps

Two small metal sample dishes

A littlesodium hydroxide solution 0.1 mol dm-3 (irritant)

Universal indicator solution

A little mineral wool.

**Safety**

Wear eye protection.

Take care if you have to insert glass tubing into the stoppers yourself. Make sure that your teacher shows you the correct technique.

**What to do**

1. Pour 125 cm3 of distilled water into the 250 cm3 flask and add 10 cm3 of universal indicator. Add one drop of 0.1 mol dm-3 sodium hydroxide solution and gently swirl the flask so that the colour of the solution is violet or at the most basic end of the universal indicator colour range.
2. Place 10 cm3 of this solution into the boiling tube.
3. Assemble the apparatus illustrated in Figure 1, attaching it to the filter pump with the vacuum tubing.
4. Place 2 cm3 of biodiesel onto a wad of mineral wool in the metal sample cup.
5. Turn on the water tap so the filter pump pulls air through the flask and ignite the biodiesel. Position the funnel directly over the burning fuel, so as to capture the fumes from the burning fuel.  Mark or note the position of the tap handle so you can run the pump at the same flow rate later in the experiment.
6. Allow the experiment to run until the universal indicator turns yellow and time how long this takes.
7. Record what happens in the funnel and in the glass tube containing the second piece of mineral wool.
8. Clean the apparatus, and repeat the experiment using 2 cm3 of kerosene (this is very similar to diesel fuel).

**Activity 3: Potential for biofuels**

|  |
| --- |
| **1.Technical Feasibility** |
| Can be blended in any ratio with petro-diesel |
| Existing storage facilities and infrastructure for petro-diesel can be used with minor alteration. |
| From environment and emissions point of view it is superior to petro-diesel. |
| It can provide energy security to remote and rural areas. |
| It has good potential for employment generation |
| **2.Sources of Bio-diesel** |
| All Tree Bearing Oil (TBO) seeds – edible and non edible |
| **Edible:** Soya-bean, Sun-flower, Mustard Oil etc. |
| **Non-edible:** Jatropha Curcas, Pongemia Pinnata, Neem etc. |

|  |
| --- |
| Edible seeds can’t be used for bio-diesel production in our country, as its indigenous production does not meet our current demand. |
| Among non-edible TBO, Jatropha Curcas has been identified as the most suitable seed for India. |
| **3.Advantages of Jatropha** |
| Jatropha Curcas is a widely occurring variety of TBO |
| It grows practically all over India under a variety of agro climatic conditions. |
| Can be grown in arid zones (20 cm rainfall) as well as in higher rainfall zones and even on the land with thin soil cover. |
| Its plantation can be taken up as a quick yielding plant even in adverse land situations viz. degraded and barren lands under forest and non-forest use, dry and drought prone areas, marginal lands, even on alkaline soils and as agro-forestry crops. |
| It grows as a tree up to the height of 3 – 5 mt. |
| It is a good plantation for Eco-restoration in all types wasteland. |
| **4.Agro Practices** (as per NOVOD, Ministry of Agriculture, GOI) |
| **Nursery raising** |
| Nurseries may be raised in poly-bags filled with mixture of soil and farm yard manure in the ratio of 4:1. |
| Two seeds are sown in each bag. |
| **Plantation** |
| 30 cm x 30 cm x 30 cm pits are dug |
| Farm yard manure (2-3 kg), 20 gm urea, 12 gm Single Super Phosphate (SSP) & 16 gm Mono Phosphate (MP) |
| **Planting density** |
| 2500 plants / ha at 2m x 2m |
| **Transplantation** |
| It should be done during rainy reason. |
| **Fertilizer** |
| From second year in the ratio of 40:60:20 Nitrogen Phosphorous and Potassium (NPK) kg/ha |
| **Irrigation** |
| It is required only for the first two years |
| **Pruning** |
| During first year when branches reach a height of 40-60 cms |
| **Pest & Disease control** |
| No disease or insects noticed to be harmful |
| **Flowering and fruiting** |
| Flowering: Sept.- Dec. & March- April |
| **Fruiting** |
| After 2 months of flowering. |
| **5.State-wise area undertaken by NOVOD for Jatropha Plantation** |
| |  |  | | --- | --- | | **State** | **Area (ha)** | | Andhra Pradesh | **44** | | Bihar | **10** | | Chhatisgarh | **190** | | Gujarat | **240** | | Haryana | **140** | | Karnataka | **80** | | Madhya Pradesh | **260** | | Maharashtra | **150** | | Mizoram | **20** | | Rajasthan | **275** | | Tamil Nadu | **60** | | Uttaranchal | **50** | | Uttar Pradesh | **200** | |
|  |
| **Economics (as per Planning Commission Report on Bio-fuels, 2003)** |
| |  |  |  |  | | --- | --- | --- | --- | | **Activities** | **Rate(Rs. / Kg)** | **Quantity(Kg)** | **Cost(Rs.)** | | Seed | **5.00** | **3.28** | **16.40** | | Cost of collection & oil extraction | **2.36** | **1.05** | **2.48** | | Less cake produced | **1.00** | **2.23** | **(-) 2.23** | | Trans-esterification | **6.67** | **1.00** | **6.67** | | Less cost of glycerin produced | **40 to 60** | **0.095** | **(-) 3.8 to 5.7** | | Cost of Bio-diesel per kg |  |  | **19.52 to 17.62** | | Cost of Bio-diesel per litre (Sp. Gravity 0.85) |  |  | **16.59 to 14.98** | |
|  |
| **7. Employment potential** (as per Planning Commission report on bio-fuels, 2003)) |
| Likely demand of petro diesel by 2006-07 will be 52 MMT and by 2011-12 it will increase to 67 MMT. |
| 5% blend of Bio-diesel with petro diesel will require 2.6 MMT of Bio-diesel in 2006-07 |
| By 2011-12, for 20% blend with Petro-diesel, the likely demand will be 13.4 MMT. |
| To meet the requirement of 2.6 MMT of bio-diesel, plantation of Jatropha should be done on 2.2 – 2.6 million ha area. |
| 11.2 – 13.4 million ha of land should be covered by 2011 – 12 for 20% bio-diesel blending |
| It will generate following no. of jobs in following areas. |
| |  |  |  |  | | --- | --- | --- | --- | | **Year** | **No. of jobs in plantation** | **In maintenance** | **Operation of BD units** | | 2006-07 | 2.5 million | 0.75 million | 0.10 million | | 2011-12 | 13.0 million | 3.9 million | 0.30 million | |
| **Oil content** |
| 35% to 40% |
| **Collection and processing** |
| Ripe fruits collected from trees. |
| **8. Efforts of National Oilseed and Vegetable Oil Development Board (NOVOD)** |
| Systematic state/region wise survey for identification of superior trees and superior seeds. |
| Maintenance of record on seeds/trees. |
| Samples of high yield to be sent to National Bureau of Plant Genetic Resources (NBPGR) for accession and cryo-preservation. |
| **NOVOD has developed improved Jatropha seeds, which have oil contents up to 1.5 times of ordinary seeds.** |
| However, being in short supply, initially these improved Jatropha seeds would be supplied only to Agricultural Universities for multiplication and development. |
| After multiplication these would be supplied to different states for further cultivation. This program is likely to take 3 – 4 years. |
| It is also working for development of multi-purpose post-harvest technology tools like decorticator and de-huller, which would further improve oil recovery. |
| **9. Trans-esterification Process** |
| |  |  |  |  |  | | --- | --- | --- | --- | --- | | **Vegetable Oil** | **Alcohol** | **Catalyst(Sodium or Potassiu m Hydroxide)** | **Glycerin(Used for medicinal value)** | **Bio-diesel** | | 100 gm | **12 gm** | **1 gm** | **11 gm** | **95 gm** | |
| It is the displacement of alcohol from an ester by another alcohol in a similar process to hydrolysis. |
| Vegetable Oil i.e. the triglyceride can be easily trans-esterified in the presence of alkaline catalyst at atmospheric pressure and at temperature of approximately 60 to 70oC with an excess of methanol. |
| If 100 gm of vegetable oil is taken, 1 gm of the alkaline catalyst (Potassium Hydroxide), and 12 gm of Methanol would be required |
| As a first step, the alkaline catalyst is mixed with methanol and the mixture is stirred for half an hour for its homogenization. |
| This mixture is mixed with vegetable oil and the resultant mixture is made to pass through reflux condensation at 65oC. |
| The mixture at the end is allowed to settle. |
| The lower layer will be of glycerin and it is drain off. |
| The upper layer of bio-diesel (a methyl ester) is washed to remove entrained glycerin. |
| The excess methanol recycled by distillation. |
| This reaction works well with high quality oil. If the oil contains 1% Free Fatty Acid (FFA), then difficulty arises because of soap formation. If FFA content is more than 2% the reaction becomes unworkable. |
| Methanol is inflammable and Potassium Hydroxide is caustic, hence proper and safe handling of these chemicals are must. |
| **10. Agencies & Institutes working in the field of bio-diesel** |
| National Oil seeds and Vegetable Oil Board, Gurgaon |
| PCRA – Petroleum Conservation Research Association (MOP&NG) |
| IOC (R&D) Centre, Faridabad |
| Delhi College of Engineering |
| IIT, Delhi |
| IIP, Dehradun |
| Downstream National Oil Companies |
| Indian Institute of Chemical Technology, Hyderabad |
| CSIR |
| Ministry of Non-conventional Energy Sources |
| Central Pollution Control Board |
| Bureau of Indian Standards |
| Indian Renewable Energy Development Agency |
| **States, which have made some lead** |
| **Uttranchal:** |
| Uttaranchal Bio-fuel Board (UBB) has been constituted as a nodal agency for bio-diesel promotion in the state. |
| Has undertaken Jatropha plantation in an area of 1 lakh hectare. |
| UBB has established Jatropha Gene Bank to preserve high yielding seed varieties. |
| Has ambitious plan to produce 100 million liters of bio-diesel. |
| **Andhra Pradesh:** |
| Govt. of AP (GoAP) to encourage Jatropha plantation in 10 rain shadow districts of AP |
| Task force for it has been constituted at district and state level |
| GoAP proposed Jatropha cultivation in 15 lakh acres in next 4 years |
| Initial target is 2 lakh acres |
| Irrigation to be dovetailed with Jatropha cultivation |
| 90% drip subsidy is proposed |
| Jatropha cultivation to be taken up only in cultivable lands with existing farmers. |
| Crop and yield insurance is proposed |
| **Chhattisgarh:** |
| 6 lakh saplings of Jatropha have been planted with the involvement of State’s Forest, Agriculture, Panchayat and Rural Development Departments |
| As per the Deputy Chairman, State Planning Board, the state has the target to cover 1 million ha of land under Jatropha plantation |
| Ten reputed bio-diesel companies, including the UK-based D1 Oils, have offered to set up Jatropha oil-extraction units or to buy the produce from farmers in Chhattisgarh. |
| Companies like Indian Oil, Indian Railways and Hindustan Petroleum have each deposited Rs 10 lakh as security for future MoUs with the state government. |
| **11. Farmers’ Initiatives in Haryana** |
| Farmers in Haryana have formed NGOs and cooperatives for promotion of Jatropha plantation. |
| These NGOs and cooperatives are raising nurseries for Jatropha plantation and supplying saplings to others for further cultivation. |
| They have been blending directly Jatropha Oil into diesel fuel and successfully using this blend in their tractors and diesel engines without any problems. |
| These NGOs and cooperatives are also organizing the practical demonstration of this usage in their demonstration workshops. |
| They are organizing local seminars, workshops and conferences etc. to promote the usage of Jatropha oil. |
| NGOs have also printed some booklets on Jatropha plantation. |
| **12. Current usages of bio-diesel / Trials & testing of bio-diesel** |
| Usages of bio-diesel are similar to that of petro-diesel |
| Shatabadi Express was run on 5% blend of bio-diesel from Delhi to Amritsar on 31st Dec. 2002 in association with IOC. |
| Field trials of 10% bio-diesel blend were also done on Lucknow-Allahabad Jan Shatabdi Express also through association with IOC. |
| HPCL is also carrying out field trials in association with BEST |
| Bio-Diesel blend from IOC (R&D) is being used in buses in Mumbai as well as in Rewari, in Haryana on trial basis . |
| CSIR and Daimler Chrysler have jointly undertaken a successful 5000 km trial run of Mercedes cars using bio-diesel as fuel. |
| NOVOD has initiated test run by blending 10% bio diesel in collaboration with IIT, Delhi in Tata Sumo & Swaraj Mazda vehicles. |

**BIO-PETROL**

Introduction

Measures to be implemented to resolve the problem of sewage sludge that contain a high degree of organic matter could primarily aim at recycling it through a thermo chemical pyrolysis process in order to recover hydrocarbons that make up the structure of sewage sludge. Pyrolysis of sewage sludge produces oil, gas and char products. The pyrolysis oils have also been shown to contain valuable chemicals in significant concentrations and hence may have the potential to be used as chemical feedstock. The production of a liquid product increases the ease of handling, storage and transport.

The technology, improved by BioPetrol Ltd. (patent pending) is capable of processing carbon wastes, other than sewage sludge, including agri-wastes, bagasse, pulp and paper residues, tannery sludge and other end-of-life products such as plastics, tires and the organics in municipal solid waste.The process of low temperature thermochemical conversion of municipal sewage sludge to oil is a new technology in developed countries. The amount of investment is still less than the amount invested in the sewage sludge incineration process, and the operational economy of the process is obviously superior to incineration.

The BioPetrol, Ltd. integrated thermochemical process (patent pending) recovers about 1,100,000 Kcal from each 283 kg of sewage sludge 90% D.S. after the thermal evaporating of 717kg water from each dewatered ton (1,000 kg) of sewage sludge 26% D.S.

The BioPetrol process begins with sewage sludge at 90% D.S. Sewage sludge drying equipment is used commonly for the evaporative removal of interstitial water from the sludge. Numerous drying technologies exist on the market.

**Market Analysis and Strategy**

Three potential products/services:

1. Disposal of Sewage Sludge – Disposal of sewage sludge comprises over 30% of wastewater treatment plants’ budget. Customers of this service are local communities. They are willing to pay top dollar for the disposal of their sludge. For example: Holland $50-$90 per ton, U.S., Canada and Australia, up to $150 per ton. The US produces 25 million tons of sludge annually (2001).

2. Synthetic Crude Oil – Excess crude oil, beyond what is being recirculated to run equipment A+B is about 30 kg per 1 ton sewage sludge 90% D.S. Oil energy = 8,900 Kcal/kg same as diesel oil used in heavy industry. There are references in professional literature to numerous valuable chemicals in significant concentration that are present in pyrolysis oils.

BioPetrol Ltd has on board, as a shareholder, an internationally renowned scientist-academician to address this issue.

3. Selling the Technology – With the completion of the development of the process and equipment for its operation, BioPetrol. Ltd. will have the technology to sell to world markets. Potential markets are water authorities, municipalities, wastewater treatment plants, entrepreneurs, sewage sludge disposal contractors, sludge drying operators.

BioPetrol, ltd. has been awarded a grant of $300,000 for a period of 2 years by Israel’s Office of the Chief Scientist to conduct advanced R&D. The company has concluded and proved the viability of the process and is now on the verge of constructing a demonstration pilot for a continuous process.

BioPetrol is seeking an investment of US$400,000 for the completion of the demonstration pilot. A business plan is available for further details.

**Technology**

The technological processes at issue in the Bio-Petrol project belong to the sphere of liquefying carbon-rich solid fuels. The liquefaction processes common today comprise two stages:

1. Thermal breakdown of the molecular structure to create radical fractions different in size.

2. Stabilization of the radicals by recombining themselves or by redistribution of hydrogen from the raw material itself or by hydrogen that is introduced from outside (molecular hydrogen or from hydrogen-donor matter).

Bio-Petrol Company has carried out R&D work which has resulted in the formulation of a suitable process for producing synthetic oil from sewage sludge with larger output than that obtained from the common process-i.e. pyrolysis. By integrating familiar liquefaction methods the company developed a process of high utilization of the organic matter that is in the sewage sludge that produces oil and gas in larger quantities and of better quality.

**What is Ethanol?**

Ethanol is part of a category of molecules called alcohols. The simplest alcohol is called methanol and is very similar to a compound called methane. Methane is a molecule composed of one carbon atom surrounded by 4 hydrogen atoms. In methanol, one of these hydrogen atoms is replaced with an oxygen atom with a hydrogen atom attached to it. This two atom group, oxygen attached to a hydrogen, is called an alcohol group.

Any molecule that has an alcohol group attached to it can be called an alcohol. To make it easier to talk about, chemists add an “ol” on the end of a chemicals name to indicate that it has an alcohol group. Therefore, methane with an alcohol group attached is called methanol.

For ethanol, it is an ethane molecule –two carbon atoms, with six hydrogen atoms surrounding them—with one hydrogen replaced by an alcohol group. Then, the name ethane is changed to ethanol, to indicate that it is an alcohol.

**How Ethanol is Made**

Ethanol has been used by humans for thousands of years, in part because it is easy to make. In fact, nature can make it for us in a process called fermentation.

Fermentation is a biochemical process carried out by microscopic organisms called yeast. Yeast are anaerobic, meaning they can live and eat without needing oxygen. Many living things eat sugar, and yeast eat sugar too. When there is no oxygen, yeast chow down on sugar, but they can’t get all of the energy that is available in sugar out of it. Instead they use it to get some energy, and in the process of digesting it, convert it into ethanol and carbon dioxide Petrol.

Yeast are even used to make bread. When making bread, bakers use the yeasts ability to make carbon dioxide Petrol to make the bread rise, making it thicker. If it were not for yeast, pizza dough would be flatter than a pancake.

Scientists have also invented ways to make ethanol synthetically, without utilizing nature’s help. The process converts a byproduct of making Petrololine into ethanol. Although this process is used, more than 90% of the ethanol produced per year is made using yeast.

**Replacing Petrololine with Corn?**

Yeast only consume simple sugars, so only certain foods are good for putting them to work making ethanol. Bakers use the sugar that you can find in your kitchen. But it takes a lot of kitchen sugar to fill the tank of your car with ethanol. Some countries, such as Brazil, that grow a lot of sugar use it to make ethanol for cars. Brazil has been producing ethanol fuels for decades. The United States does not have enough sugar cane plants to do this. Instead, the U.S. has focused on using corn.

Corn has less sugar in it than sugar cane, requiring scientists to develop ways to convert corn’s more complex sugars into simple sugars. Critics of using corn for fuel say that it takes more energy to make ethanol from corn than it takes to make regular Petrololine.

However, a recent review of many different studies in the American Chemical Society journal, Environmental Science and Technology, suggests that in most cases, using corn would still save us from using as much fossil fuels as we would if we just used Petrololine.

**Sticks, husks, and grass to Ethanol?**

A new method is being developed that may be even more promising than using corn or sugar cane as yeast food. All plants make a complex sugar called cellulose and it is one of the most abundant plant materials on earth. Cotton is almost all cellulose, and some forms of cellulose can be found in many of the foods that we eat. Trees have it. Grass has it. Even corn stalks. But yeast don’t eat cellulose.

Recently several groups of researchers have developed enzymes, which are complex molecules that operate like little machines, to break apart cellulose into simple sugars that the yeast can eat.

What makes this very interesting is that farms and other industries already produce tons and tons of waste materials that contain cellulose. Just imagine, all the sticks and grass clippings from your yard or playground could be turned into fuel for your car. Farms can also grow plants for making ethanol. President George W. Bush mentioned one of these, switch grass, in the 2006 State of the Union address.

Therefore, farms or timber companies can convert their waste into ethanol. There is also one additional benefit, and challenge to processing cellulose. Cellulose is often stuck together with another plant compound called lignin. Lignins are compounds that make plants strong, and they trap cellulose. Lignins are one of the waste products of papermaking. But, lignin materials extracted from waste materials used for making ethanol can be burned to power the process, saving more fossil fuels.

It’s not a question of if we will stop using oil but when. Soon, we will all have to replace oil with a different, renewable source and ethanol may be the answer.

\*\*\*\*THE END\*\*\*\*