Chemistry

Investigatory Project

By –

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Certificate

This is to certify that this "Chemistry Investigatory Project" has been successfully completed by *Dhananjay Dhiman* of class *XII – A* under the guidance of *Mr. B. Venkaiah* in particular fulfilment of the curriculum of Central Board of Secondary Education {CBSE} leading to the award of annual examination of the year *2016-17.*

Teacher In-Charge **External Examiner**

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OBJECTIVE

The objective of this project is to study *Green Chemistry – Bio Diesel & Bio Petrol* and also to study *Extraction process of Bio Diesel.*

INTRODUCTION TO GREEN CHEMISTRY

One of the most important new aspects of chemistry is the development of GREEN CHEMISTRY supported by the American Chemical Society, the USEPA and other federal agencies. GREEN CHEMISTRY has emerged as an important aspect of all chemistry. GREEN CHEMISTRY is the design of chemical products and processes that reduce or eliminate the use and generation of hazardous substances.

GREEN CHEMISTRY is based on twelve principles.

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 Synthesis

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 affect 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/ non-protection, 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 stoichiometric reagents.

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.

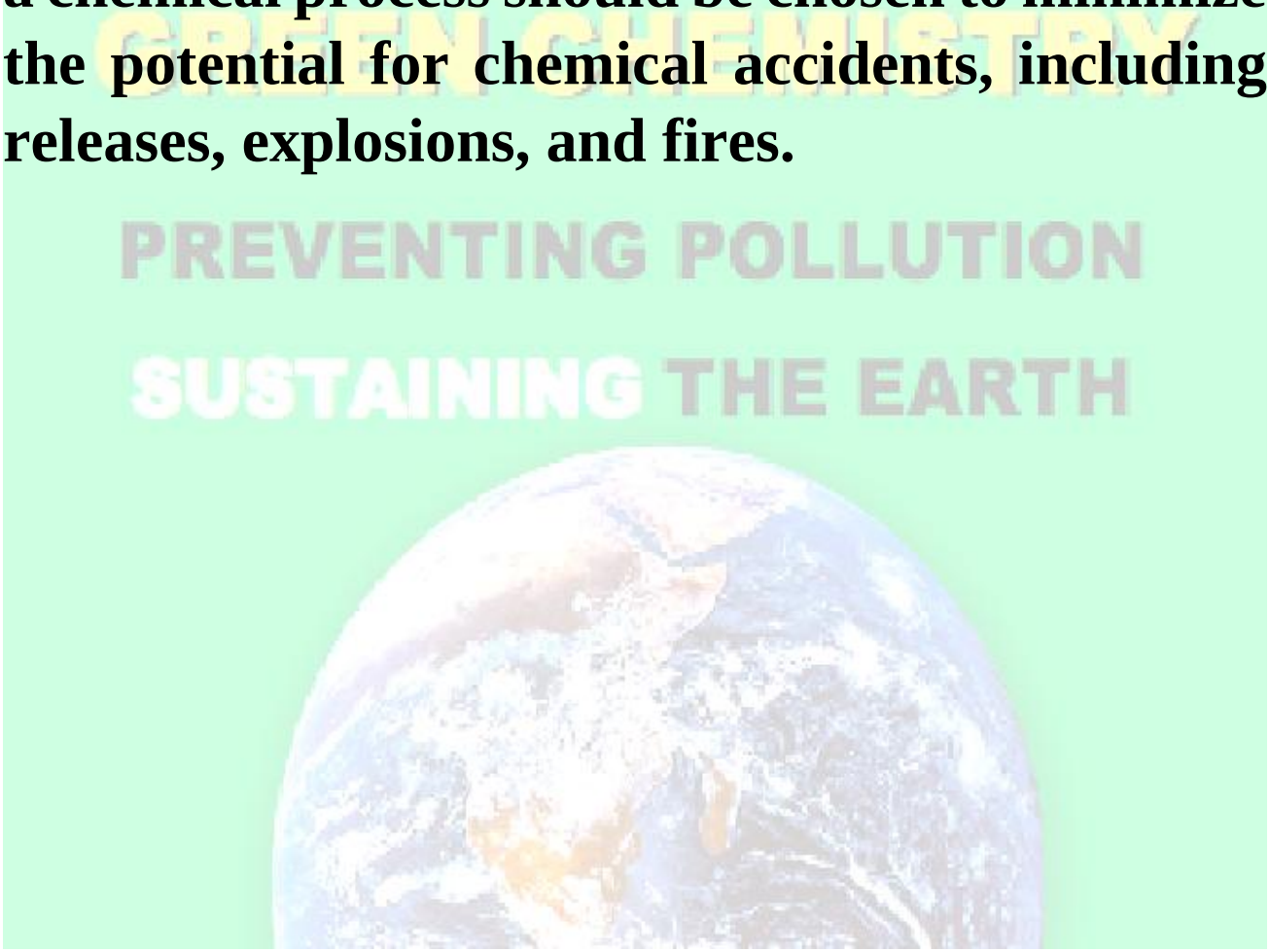
11. Real-time analysis for Pollution Prevention

Analytical methodologies need to be further developed to allow for real-time, in process

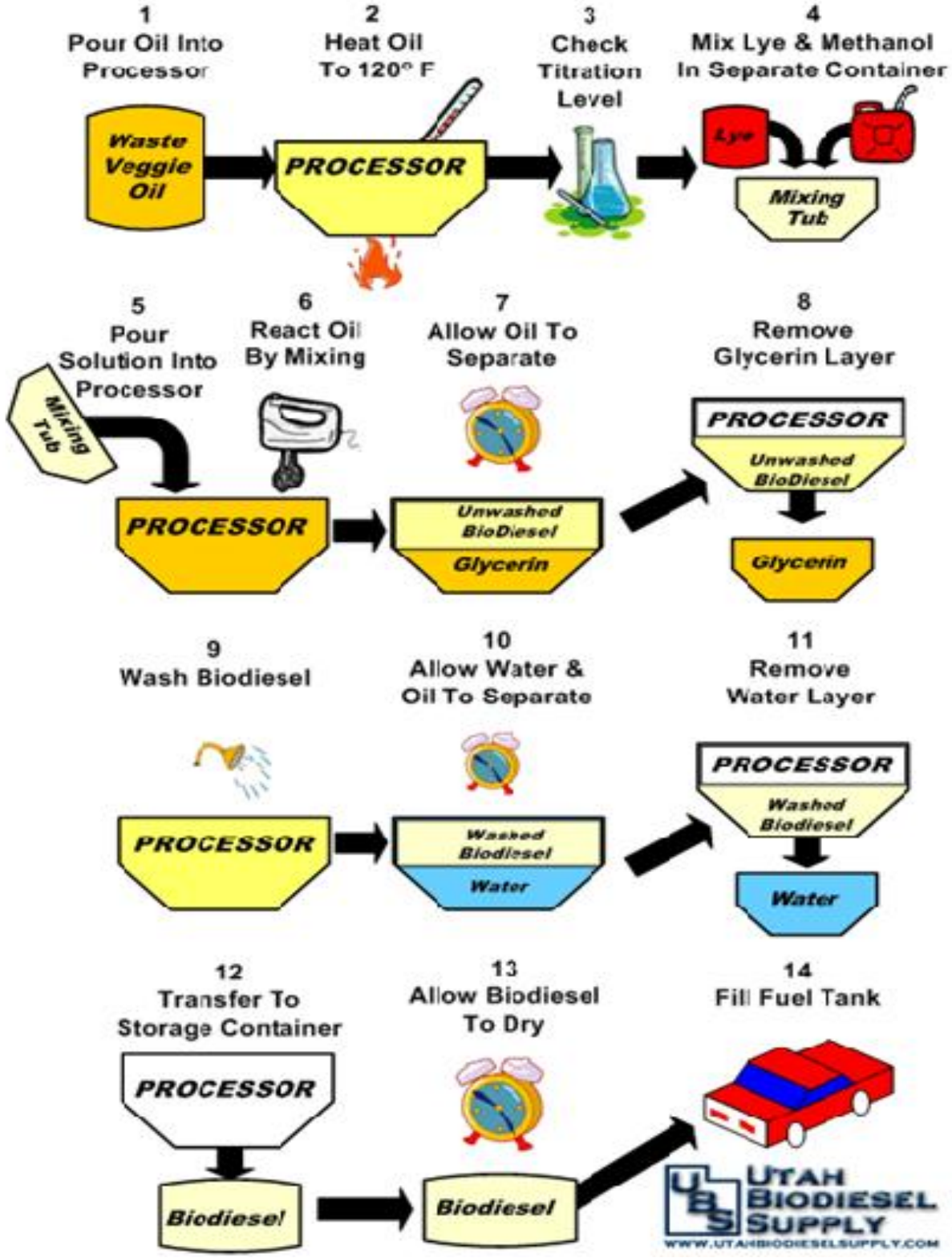
monitoring and control prior to the formation of hazardous substances.

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.



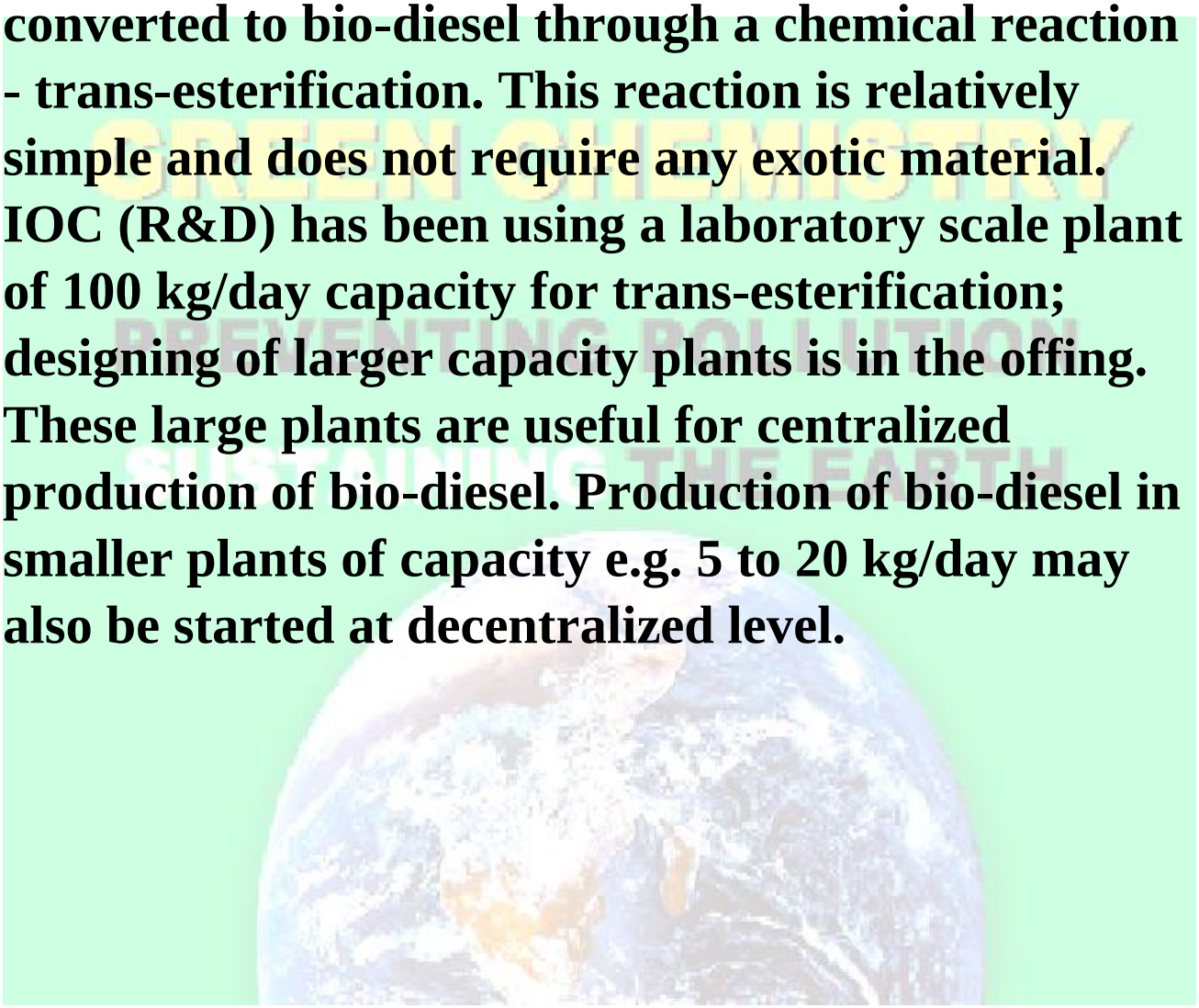
BIO DIESEL: USING RENEWABLE RESOURCES



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 compared, show striking similarity to petroleum derived diesel and are called "Bio - diesel". As India is deficient in edible oils, non-edible oil may be the material of choice for producing bio diesel. For this purpose, Jatropha Curcas is considered as most potential source for it. Bio diesel is produced by transesterification of oil obtained from the plant. Jatropha Curcas has been identified for India as the most suitable Tree Borne Oil seed (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 upgradation 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 BIO DIESEL

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 cm^3 conical flask**
- **Two 100 cm^3 beakers**
- **One 100 cm^3 measuring cylinder**
- **Five plastic teat pipettes**
- **Distilled or deionized water**
- **100 cm^3 vegetable-based cooking oil**

- **15 cm^3 methanol (highly flammable, toxic by inhalation, if swallowed, and by skin absorption)**
- **1 cm^3 potassium hydroxide solution 50% (corrosive).**

➢ Safety Measures:

- **Wear eye protection.**
- **Methanol is flammable and poisonous.**
- **Potassium hydroxide is corrosive.**

➢ What to Do:

1. Measure 100 cm^3 of vegetable oil into the 250 cm^3 flask. Weigh the flask before and after to determine the mass of oil you used.

2. Carefully add 15 cm^3 of methanol.

3. Slowly add 1 cm^3 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.

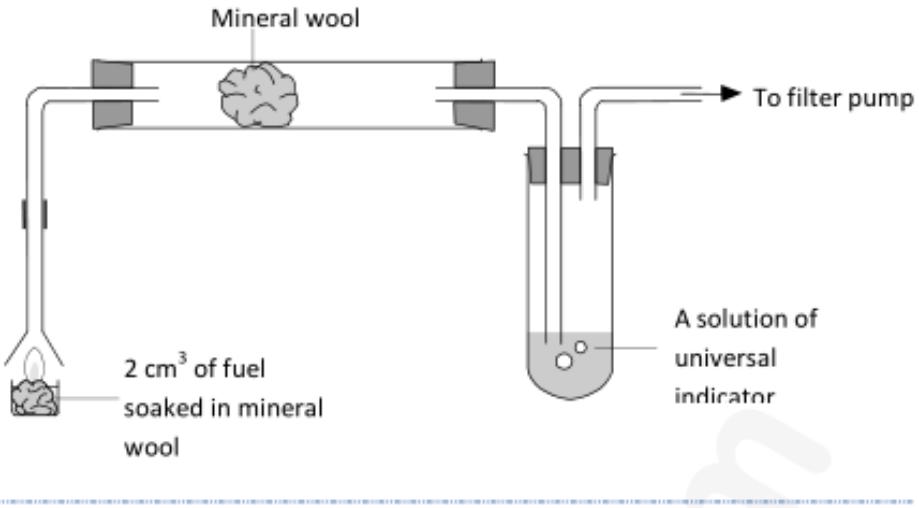
6. Carefully remove the top layer (this is impure biodiesel) using a teat pipette.

7. Wash the product by shaking it with 10 cm^3 of distilled or deionized 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 BIO DIESEL

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 in diameter)**

- **One 250 cm^3 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 the flask)**
- **Two stands and clamps**
- **Two small metal sample dishes**
- **A little sodium hydroxide solution 0.1 mol dm^{-3} (irritant)**
- **Universal indicator solution**
- **A little mineral wool.**

➢ Safety Measures:

- **Wear eye protection.**

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

- **<u>What to Do:</u>**

1. Pour 125 cm^3 of distilled water into the 250 cm^3 flask and add 10 cm^3 of universal indicator. Add one drop of 0.1 mol dm^{-3} sodium hydroxide solution and gently swirl the flask so that the color of the solution is violet or at the most basic end of the universal indicator color range.

2. Place 10 cm^3 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 cm^3 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 ignites 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 note the 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 cm^3 of kerosene (this is very similar to diesel fuel).

ACTIVITY 3: POTENTIAL FOR BIO FUELS

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 Biodiesel –

-- 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 meters.

-- It is a good plantation for Eco-restoration in all types wastelands.

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

6.

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 cryopreservation.

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 70^{o}C 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 65°C.

- 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 biodiesel

-- 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:

Uttaranchal:

- 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 (Go AP) to encourage Jatropha plantation in 10 rain shadow districts of AP
- Task force for it has been constituted at district and state level Go AP 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 biodiesel / Trials & testing of biodiesel:

-- Usages of bio-diesel are similar to that of petro-diesel

-- Shatabdi 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 thermochemical 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 Bio Petrol Ltd. (patent pending) is capable of processing carbon wastes, other than sewage sludge, including agro-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 Bio Petrol, 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 Bio Petrol 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. <u>Disposal of Sewage Sludge</u> – 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. <u>Synthetic Crude Oil</u> – 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. Bio Petrol Ltd has on board, as a shareholder, an internationally renowned scientist-academician to address this issue.

3. <u>Selling the Technology</u> - With the completion of the development of the process and equipment for its operation, Bio Petrol. 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.

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 are 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.

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.

GREEN CHEMISTRY WORKS TOWARD SUSTAINABILITY BY:

- Designing more efficient processes that minimize the production of waste materials.

GREEN CHEMISTRY WORKS TOWARD SUSTAINABILITY BY:

- Making chemical products that do not harm either our health or the environment,
- Using industrial processes that reduce or eliminate hazardous chemicals, and

IN SUMMARY, GREEN CHEMISTRY IS...

- Scientifically sound,
- Cost effective, and
- Leads toward a sustainable civilization.

Conclusion

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End of Project

Thank you...!