Utilization of Vegetable and Fruit Waste for Bio-Energy Generation

Sneha Chafle, Vinayaka Parmar, and Seemab Biya
MGM's Jawaharlal Nehru Engineering College, Aurangabad (M.S.)-431003
Third Year Department of Chemical engineering
Email: {enjoysneha03, parmarvinayaka, bseemab}@gmail.com

***Abstract*—We have gone through decades of energy crisis, without any adequate policy for conservation of gasoline and other petroleum products. The only solution left is to restrict ourselves to renewable sources of energy and find a substitute for them. Bio-fuels are the future source of energy all around the world. Globally, more than 30% of the loss occurs at the retail and the land consumer levels, of which the post-harvest and processing level wastages account for the major share. The process includes extraction of oil from castor seeds containing about 80% glyceride, followed by production of ethanol from sweet potatoes. Further process includes trans-esterification that shows the highest potential for the production of bio-fuel, the need of the hour for fueling the future. The studies involve the technology of "waste to fuel" with a view to overcome the disposal problems. The present article deals with the studies conducted on vegetable wastes for production of bio-fuel.**

***Index Terms*—bio-fuel, extraction, glyceride, trans-esterification**.

I. Introduction

Bio-diesel is a clean, non-toxic and renewable fuel and is made from plant oil source with its further blending with ethanol. It has various benefits when it comes to environment point of view; it substantially reduces the emission of green house gases which includes carbon monoxide and carbon dioxide as major constituents. Bio-diesel proves to provide a dormant plat-form for the various bio-industrial products which can develop the economy. The challenge is to identify these opportunities and take them to a global market-place. Pure bio-diesel has low aquatic toxicity, and is bio-degradable. Processing waste for the production of bio-diesel facilitates the recycle of waste. [1], [3], [4]

II. Fuel Efficiency

Bio-diesel can be directly used in the engines in its purest form. It is often blended with petroleum to certain percentage (B20-20% blended fuel). Lubricity is the major concern when it comes to vehicles running on gasoline. Various additives are introduced to increase the efficiency of the fuel, but at the same time with biodiesel acting as adulate serves as the solution to the existing problem of lubricity. The performance of 100% bio-diesel is found lower because of its lower energy content when compared to petroleum diesel. This is due to the fact that bio-diesel contains oxygen, and has 8% of lower energy content than the petroleum. [2]

III. Compatibility with Engines

Bio-diesel can be used in regular engines with slight modifications because of the solvent effect. The solvent effect of bio-diesel may release the accumulations on the tank walls formed because of previous petroleum diesel and lead to clogging of the engines. Changing the fuel filters can serve as a solution to the problem.

IV. Production Process

The production process of bio-diesel can be divided into three main procedures:

A. Extraction of oil from vegetables[6]
B. Preparation of ethanol from sweet potatoes.[8]
C. Trans-esterification process[10]

A. Extraction of Oil from Waste Vegetables

The feed-stock to be chosen for the production of bio - diesel which includes the extraction of oil as the primary step is the major concern. Among the various available seeds eg. Soyabean, mustard, and castor seed it was found that castor seed has the highest amount of tri-glyceride content. Castor seeds are readily available in the forest and require tropical type of climate for its growth. It is a khariff season crop. Hot and humid climatic conditions are favorable for cultivation of castor seeds and India is gifted with the same and stands as one of the leading producers, producing almost about 65% of the total production in the world.

Firstly, the castor fruits as shown in Fig. 1. Are separated from plants and are dried for about 10-15 days. The dried fruit is then split open from which castor seeds are obtained. The seeds contain 48% of oil and the rest becomes the part of oil cake. The seeds are pressed to yield the oil and the remaining cake is subjected to differential distillation for further extraction of oil. The remains after the distillation can be used as manure for

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agriculture of crops just that of like wheat and maize [5], [7]

Figure 1. Castor fruits

B. Preparation of Ethanol from Sweet Potatoes

Sweet potatoes are used for the production of alcohol as it is feasible and cost-effective. It contains 22% starch, 5-6%sugar and a total of 27-28% of fermentable material. It includes three steps:

Cooking of sweet potatoes

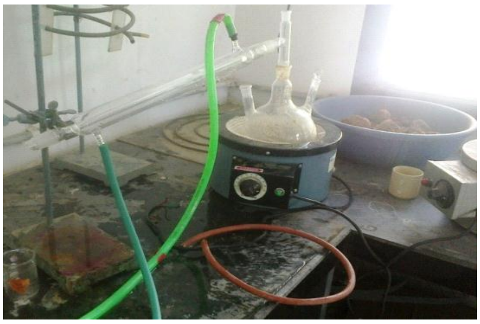

Figure 2. Setup for ethanol production

Sweet potatoes are washed with water to remove the adhering dirt and unwanted material. And then is subjected to cutting, small and even pieces are cut for even cooking in the cooking vessel. Approximately 200 ml of water is added to 200gram of sweet potato for cooking. And allow it to boil slowly for 50-60 minutes. Cook it until it becomes soft and mash.Efficient stirring is preferred to avoid sticking of mash to the bottom of vessel.

Dilution

Dilution is addition of water to the mash in-order to adjust the sugar level and to make the slurry preferentially thin which gets thickened, because of the conversion of starchy material for better handling and stirring. It also ensures that the yeast is not killed as the fermentation proceeds due to high concentration of alcohol.400ml is added for 200 grams of mash. It is further allowed to cool in same vessel till it reaches 45°C.2gram of yeast is also added to the diluted mash prepared at the same temperature.

Fermentation

The prepared mash with yeast is kept in a 1litre flask for microbial fermentation.

Distillation

The mixture of alcohol and water obtained is subjected to steam distillation as shown in Fig. 2.

C. Trans-Esterification Process

In the process tri-glyceride which are present in the oil obtained in the first step are made to react with the alcohol prepared in the second step to produce a mixture of fatty acid alkyl ester and glycerol. 1 mole of tri-glyceride requires 3mole of alcohol for trans-esterification to proceed yielding 1 mole of product. Percentage of yield depends upon the percentage of alcohol in the reaction. Excess of alcohol used in the process allows the phase separation of alkyl ester and glycerol. The overall process consists of three reactions which are reversible in nature yielding two intermediates that are mono-glyceride and di-glyceride. Trans-esterification can be done by four methods:

Acid-catalyzed process

It yields complete conversion but still is not preferred because it takes higher time and greater temperature for the completion of reaction. Protonation of carbonyl group of ester produces carbocation which hinders the yield of reaction which reacts with the acid producing carboxylic acid.

Lipase catalyzed process

These are readily available and are easily handled. Their hydrolytic enzymes are widely used in organic synthesis because of their stability. But they are still not preferred because the time required for the completion of reaction and its low yielding capacity as compared to base catalyzed process.

Base catalyzed process

Base catalyzed process proceeds at a faster rate when it comes to acid catalyzed process. It is used commercially on a large scale due to its less corrosive property. Production of moles of water is observed during the reaction of oil and alcohol though they are anhydrous in nature. The water molecule formed reacts with the ester initially formed and hydrolyzes it producing soap. The undesirable formation of soap leads several difficulties in the phase separation of alkyl ester and glycerol. The soap formation can be reduced to some extent by using potassium carbonate. But it is required to be taken in more mole percentage and takes longer time for completion leaving fewer yields as compared to sodium and potassium hydroxide.

Non-ionic based catalyzed process

The non-ionic base catalyzed process is used for mild conditions and to simplify the manipulations. These catalysts are developed for organic synthesis. We have used TBD as a catalyst (i.e. 1, 5, 7 triazabicyclo[4,4,0]dec-5-ene). It is observed that one mole percent of TBD produces up to 90% of alkyl ester after a reaction time of one hour without any formation of soap as in the case of base-catalyzed process.

If 2 to 3 mole percent of TBD is used, it gives a yield of 91% and 93% respectively.TBD is used because it is more efficient than potassium carbonate at lower molar concentration with same reaction conditions which includes reaction time more dominantly. [9]

V CONCLUSION

With the exhausting fossil fuel and increase in man's need, the only solution seen as of today for shortage of fuel is bio-diesel. We can conclude that substituting bio-diesel with gasoline in the squadron of vehicles in coming years can exponentially reduce the emission of CO_2 in the atmosphere. Today there is a unique opportunity to develop a next generation bio-fuel industry. There could be major benefits in terms of economy and energy security. It cannot only make resource energy possible but also reduces the amount of waste generation. It also shows the potential to expand agriculture and also a balanced carbon-cycle. Bio-fuel is cheaper and burns safer as compared to existing fuels.

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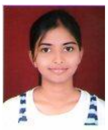

Sneha A. Chafle born in Chandrapur, Maharashtra on 12th April 1992. Currently pursuing bachelor's degree in Chemical Engineering from MGM's Jawaharlal Nehru Engineering College Aurangabad (M.S. INDIA)

Vinayaka V. Parmar born in Mainpuri, Uttarpradesh on 28th May 1992.Currently pursuing bachelor's degree in Chemical Engineering from MGMs Jawaharlal Nehru Engineering College Aurangabad (M.S. INDIA)

Seemab M. Biya born in Mumbai, Maharashtra on 24th March 1991.Currently pursuing bachelor's degree in Chemical Engineering from MGMs Jawaharlal Nehru Engineering College Aurangabad (M.S. INDIA)

