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Production of Ethanol from Sweet Potatoes

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Abstract

There is nothing new in the use of alcohol made from root crops as a motor fuel. Alcohol is an excellent alternative motor fuel for petrol engines. The reason alcohol fuel has not been fully exploited is that, up until now; gasoline has been cheap, available, and easy to produce. However, nowadays, crude oil is getting scarce, and the historic price difference between alcohol and gasoline is getting narrower. Alcohol fuel can be an important part of the solution for problem and this alcohol has many sources of production like sugar cane, switch grass, sugar beets, sweet potato and corn. There is tremendous scope to use bulk production of sweet potato into alcohol. The total sweet potato production in both seasons is found to be 1,607,296 tones/year. The average productivity of Sweet potato in the country irrespective of seasons is found to be 8.9 tones/ha.so,as the crop is abundantly available and the sweet potato can be readily converted into the alcohol we conclude that this method is recent sensation in the renewable energy sources Keywords:

Keywords: Sweet potato; Bioethanol; Alcoholic fermentation; Simultaneous saccharification and fermentation (SSF).

Introduction

From the past decade many nations has been facing the problem on non-renewable energy sources and research is going on in such a direction that there is a search for such a source which can replace the non-renewable energy source efficiently and can be produced enormously from the renewable sources which is eco-friendly and will not have any drastic effect over environment. This is why alternative source of energy receive more and more attention today from the government of many nations .The alternative energy thus created from the renewable source is treated as the way to lower the total cost of energy and to reduce the dependence from the imported energy resource. Ethanol is a best alternative source which can replace gasoline as it also a hydrocarbon which has the properties close to the gasoline and can blend with gasoline to give the characters which are eco-friendly and can blend with the gasoline to give the character which are eco-friendly and enhance the characteristics of the gasoline with less emission of co_2. In fact by the renewable fuels consumer protection and energy efficiency act, issued at 2007 which appeals that Americans plan to increase the production of ethanol from current 6.5 billion gallons to 36 billion gallons per year by 2022.And same with many countries such as china, Japan, & Malaysia to run their engines with ethanol and cut short the usage of non-renewable energy usage

Sources for ethanol:

Ethanol being the bio fuel it can be produced from the any plant matter which has carbohydrates and starch in it. Many countries produce ethanol from the sugar cane and corn which are important crops and they are seasonal too. Even sweet potato which an excellent resource of carbohydrate can be used for the production of alcohol some of the sources for the production of ethanol. But now a days many countries are making their efforts to produce ethanol from the sources other than plants, which can be used for the food. In this regard, cellulosic ethanol is gaining its popularity. This type of ethanol can be produced from such materials as switch grass, miscanthus, wood chips and other by products of wood processing. In fact according to the u.s law mentioned above Americans except at 60% of their ethanol to be produced from cellulose. The yield of alcohol in gallons per hectare of crop is shown in the tabular form :

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Yeild of Alcohol From One Hectare of Feed Stock

FEED STOCK	GAL/LITRE
WHEAT	340
CORN	400
SWEET SORGHAM	600
SWEET POTATOES	640
SUGAR CANE	650
SUGAR BEETS	700
SWITCH GRASS	1000
MISCANTHAS	1250

Solvent Properties

1. Ethanol is a versatile solvent, miscible with water and with many organic solvents including acetic acid, acetone, benzene, carbon tetra chloride, chloroform, diethyl ether, ethylene, glycol, glycerol, nitro methane, pyridine and toluene.
2. It is also miscible with light aliphatic hydrocarbons such as pentane andhexane and with aliphatic chlorides such as trichloroethane and tetra chloroethylene
3. Hydrogen bonding causes pure ethanol to be hygroscopic to the extent that it readily absorbs water from the air. The polar nature of the hydroxyl group causes ethanol to dissolve many ionic compounds, notably sodium and potassium hydroxides, magnesium chloride, aluminium chloride, ammonium chloride, ammonium bromide, and sodium bromide. Sodium and potassium chlorides are slightly soluble in ethanol
4. An ethanol-water solution that contains 40% ABV (alcohol by volume) will catch fire if heated to about 26 °C (79 °F) and if an ignition source is applied to it. This is called its flash point. The flash point of pure ethanol is 16.60 °C (61.88 °F), less than average room temperature.

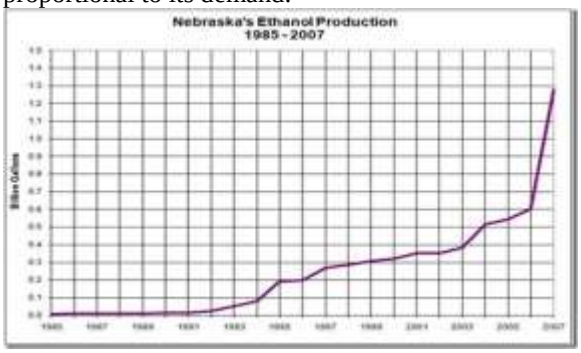
PHYSICAL PROPERTIES :

1. Ethanol is the volatile colourless liquid that has slight odour. It burns with the smokeless blue flame that is not always visible in the normal light
2. The physical properties of the ethanol are primarily due to the presence of the hydroxyl group in the shortness of its carbon chain. Ethanol hydroxyl group is able to participate in hydrogen bonding, rendering it more viscous and less volatile than less polar organic compounds of similar molecular weight, such as propane.

Demand for the Ethanol

Ethanol currently has a lot of demand because it has tendency to replace the petrol but currently this replacement is not going on but the gasoline is blended with the ethanol to enhance its properties. Due to which the world production of ethanol have increased from 13.6 billion gallons from 2007 to 22.3 billion gallons by 2012.

Ethanol production was expected to continue to grow over the next several years, since the Energy Independence and Security Act of 2007 required 36 billion US gallons of renewable fuel use by 2022. The target for ethanol production from cellulosic feedstocks was 16 billion US gallons a year. The corn ethanol target was 15 billion US gallons by 2015. Ethanol industries provided jobs in agriculture, construction, operations and maintenance, mostly in rural communities.The production of ethanol from 1985-2007 is shown in the figure below and this production is directly proportional to its demand.



The graph above shows that the demand for the ethanol is increasing day by day so there is urgent need for the search of the raw material for the production of ethanol. The raw material should have the following components in the higher amount so that they can be converted into alcohol by the suitable procedures. Sugars are the main substances that can be fermented and converted into alcohol. Some substances will be consisting of the starch which can be converted into sugars by the enzyme called as “alpha-amylase and gluco-amylase” and some substances will be consisting of the cellulose which will be broken down into sugars by the enzyme called as the lactomin. Finally all the sugars consisting in the broth will converted into alcohol and the alcohol will be concentrated to the required amount and used in the required places.

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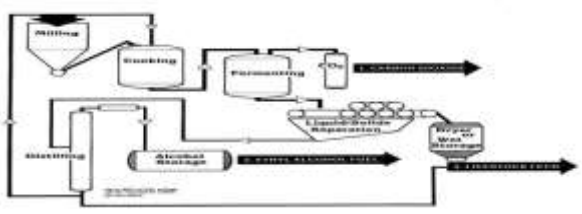
Systematic procedure for production of alcohol

1. **Pre-treatment** : This involves the removal of the soil particles and other waste material that are present on the raw material
2. **Size reduction**: the raw material thus taken is reduced in the size by cutting it into the pieces
3. **Liquefaction**: The raw material which cut is now mixed with the water in proportion and it is heated to the temperature of 30-45^{o}c so the substance is liquefied. the solution thus obtained is called as the **mash**
4. **Dilution of mash :** After obtaining the mash is diluted to required level of sugars so that yeast added may not be destroyed
5. **Saccharification:** To covert the starch present in the stem we need to use alpha gluco amylase which covert the starch into fermentable sugars
6. **Fermentation :** After saccharification then yeast is added to the solution so that the fermentation takes place where the sugars are converted into the alcohol
7. **Distillation :** The alcohol which is obtained after fermentation will be the mixture of the water and the alcohol which we need to separate is using an unit operation called as the distillation
8. **Dehydration :** Even after the distillation there will be 4% of water which cannot be removed by this distillation technique as it form an azeotrope
9. **Denaturing :** the alcohol thus made is made unfit for drinking and is still processed into such a way that is used as a fuel
10. **Collection of bi products:** the main bi product obtained in this process is carbon di oxide which is collected and bottled for its usage in beverages and flash freezing applications. This also used in fire extinguishers

Flow Sheet for Production of Ethanol by Fermentation



PRE-Treatment

The potatoes which we use as raw material are the root crop which are brought out by digging and consists of the lot of soil particles in it so the raw material is washed well with the water so that all the foreign particles will be removed. Generally washing is done twice and after washing the raw material is dried and stored for the transportation to processing unit.

Size Reduction

The raw material cleaned and brought will be of size and surface area will be less so its size is reduced by using the size reduction technique called cutting. After cutting the surface area of the raw material is increased and this is called as the meal. During cutting the temperature must not increase above 40^{o}C. Initially the potatoes are socked in the sulphuric acid for 8 hrs and then the mixture is sent into cutters for its size to be reduced .Now these pieces are sent for the ethanol production

Enzyme Hydrolysis

After reduction in the size the small pieces are brought then mixed with the water at the rate of 100 ml of water for every 200 gm of potatoes and cooked at the temperature of 30-60^{o}c.and while cooking the mash is stirred well. Then the mash is cooled to the room temperature and then it is diluted to required concentration of sugars. After dilution two enzymes alpha amylase and gluco amylase are added so that the starch in the potatoes gets converted to sugar at the temperature of 120-150^{0}c .and holding them at the temperature of 95^{o}c.

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Yeast Cultivation

Yeasts are eukaryotic microorganisms classi fied in the kingdom FungiYeasts are unicellular, although some species with yeast forms may become multicellular through the formation of strings of connected budding cells known as pseudohyphae, or false hyphae, as seen in most molds. Yeast size can vary greatly depending on the species, typically measuring 3–4 µm in diameter, although some yeasts can reach over 40 µm. Most yeasts reproduce asexually by mitosis, and many do so by an asymmetric division process called budding. Yeast is a most sensible micro organism which can grow faster but cannot survive in the slight foreign condition ,so it must be carefully cultivated and care must be taken for its survival.

Steps Yeast Cultivation

1. First of all take 200 ml of the double distilled water and sterile it for half an hour and cool the water to the room temperature.
2. Then add 20 grms of sugar and leave the batch undisturbed for a while so that the entire sugar will be dissolved
3. The add required amount of nutrients such as ammonium phosphate and sulphate which are required for the growth of yeast

Now, add some amount of yeast cells and leave it for 6 hrs maintain the pH around 4.5- 4.7 then yeast will completely growing.

In active yeast

Activated fully grown yeast

Yeast Ferimentation

1. The mash is then cooled and transferred to fermentation units
2. Yeast is added to convert the sugars to ethanol and carbon-di-oxide
3. The yeast species saccharomyces cerevisiae has been used in baking fermentation alcoholic beverages for thousands of years .it is also extremely important as a model organism in modern cell biology research, and is one of the most thoroughly researched eukaryotic microorganisms
4. The time of fermentation is 48-60 hr. The temperature maintained in this process is 30^{o}c. Ph range is 4-4.5
5. Ethanol is produced by microbial fermentation of the sugar . microbial fermentation will currently only work directly with sugars
6. Two major components of plants, starch and cellulose, are both made up of sugars and can be used in principle to convert to sugars for fermentation
7. Currently only the sugar (e.g.: sugar cane) and starch (e.g.: corn) portion can be economically converted

There is much activity in the area of cellulosic ethanol ,where the cellulose part of a plant broken down to sugars and subsequently converted to ethanol

Industrial setup for fermentation

Laboratory batch

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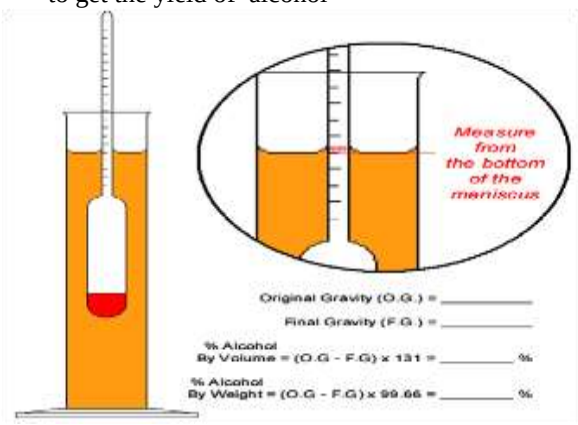
Distillation

Industrial Method for the Measurement of Alcohol Content

For the measurement of the alcohol content present in the solution obtained after the distillation there are many procedures and the procedure we use here is "specific gravity " .

Procedure

1. The solution obtained after the distillation is taken in the well dried and strile beaker
2. The beaker must be kept closed so as to avoid the external moisture mixing with the solution
3. Now a alcohol is to be taken as reference solution its specific gravity is to be measured using an hydrometer
4. Note the specific gravity of that reference solution and then measure the specific gravity of the required solution
5. Then use the formula as shown in the fig below to get the yield of alcohol



Coversion and Yeild Calculation

Contents of sweet potato :

1. Starch – 22%
2. Sugars – 5-6%
3. Fibers – 10%

Water content – 63-66%

Reactions involved for the conversion :

$(C_6H_{10}O_5)_n + nH_2O \longrightarrow nC_6H_{12}O_6$

$C_6H_{12}O_6 \longrightarrow 2C_2H_5OH + 2\,CO_2$

Amount of feed taken	= 300 grms
Amount of starch in feed	= 300*0.22
	= 66 grms
Amount of sugars in the feed	= 300*0.06
	= 18grms
Total amount of sugars	= 84grms
Molecular weight of sugar	= 180 gm/gmole
Number of moles of sugars	= 84/180
	= 0.466 moles

From the stoichiometric equation one mole of sugar should give two moles of alcohol

So, accordingly we should get	= 2*0.466
	= 0.933 gmoles
As we already know that the amount of alcohol obtained	= 14%
Number of moles of alcohol obtained	= 0.933*0.14
	= 0.1304 moles
Yield of alcohol	= 14%
Conversion of sugars	= (0.1304/0.433)*100
	= 27.9%
Therefore the yield of alcohol is	= 14%
Coversion of sugars	= 27.9%

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