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Effect of Acid Concentration on the Yield of Bio-ethanol Produced from Corncobs

Muhammad Auwal Balarabe*, Omowumi Fatima Ibuowo

Department of Pure and Applied Chemistry, Usmanu Danfodiyo University, Sokoto, Nigeria

Email address:
auwal4real72@gmail.com (M. A. Balarabe), Fatimaibuowo@gmail.com (O. F. Ibuowo)
*Corresponding author

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Abstract: The Rising energy requirements and atmospheric contaminations by combustion of gases and conventional fuel, has opened avenues for new, safe, effective and more accessible energy sources. Corn is one of the richest sources for the production of ethanol. This research looked the effect of concentration of sulphuric acid on the yield of bio-ethanol produced from the lingocellulosic material corncob which is an alternative over food derived ethanol, consumption of crude oil and environmental pollution. The main objective of this study is to know the best acid concentration to that can used during acid hydrolysis for the production of ethanol from the cellulosic content of corncobs. In this study, different condition was examined as to access their effect for optimum ethanol production. The method used was acid hydrolysis of corncobs with varied acid molarities of 0.4M, 0.6M, 0.8M and 1M. The UV/visible spectrophotometer of 1M H_2SO_4 has the highest absorbance of 0.447, followed by 0.8M (0.368), 0.6M (0.292) and 0.4M (0.253). The result obtained from the physical parameters measured for each different concentration after fermentation processes of the bio ethanol produced, 1M H_2SO_4 of the corncobs prepared produced the highest percentage yield (55.5%) of the bio ethanol followed by 0.8M (50.5%), 0.6M (47%) and 0.4M (42%) which was the lowest yield. This has shown that acid hydrolysis at 1M H_2SO_4 with moderate yeast concentration $3g/20cm^3$ at room temperature and atmosphere pressure can be used to improve the production of bio ethanol.

Keywords: Bio Ethanol, Corncobs, Fuel, Production, Fermentation, Acid Hydrolysis, Lingocellulosic

1. Introduction

The problem associated with petroleum and fossil fuel sources are that they are limited in supply and cannot be renewed, hence deplete on usage. It is therefore evident that there is the need to search for alternative fuel sources which can be renewed with time. [1] Progressing of bio-ethanol industries could help to reduce dependence on fossil fuels and moderate global warning. [2] However, Maize Stover is observed as one of the encouraging feedstock for the production of cellulosic bio-ethanol because of its high content of cellulose and hemicelluloses. [3] To reduce the not contribution of greenhouse gas to the atmosphere, bio-ethanol has been recognized as a potential alternative to petroleum derived transportation fuels and cooking fuels. [4]

Ethanol is at present the most widely used liquid bio fuel for motor vehicle. There are lots of other alternative fuels such as methanol, methane, natural gas, propane, hydrogen, etc. Nevertheless, the remarkable characteristics of ethanol distinguish it as the best alternative fuel for automobile. It has high latent heat of vaporization, high octane number rating, and emission of toxic compounds on its combustion is low. [5] Thus, when ethanol and gasoline are respectively burned incorrect stoichiometric ratio, they have about equal volumetric efficiency. When gasoline is burned, it produces water, carbon dioxide, carbon monoxide and other impurities such as oxides of sulphur and nitrogen and heavy metals. On the other hand, pure ethanol is bum to produce carbon dioxide water and a much lower amount of carbon monoxide. Hence, ethanol will be a better replacement for gasoline. [6] Production of bio-ethanol from lignocelluloses materials such as agricultural wastes though faces challenges, can substitute bio-ethanol production from edible food substance. Maize is an abundant cereal produce, and contributes large quantities of agro wastes which are underutilized. Corncobs form about 30% of maize agro wastes. [7]

Technology of bio-ethanol production from lingocellulosic biomass such as corncob, sugarcane and grasses offer great potential. [8] Production of bio-ethanol has been continually increasing during the last few years and has reached around 88.7 billion litres in 2011, thus, replacing the need for one million barrels of crude oil per day worldwide, over 90% of the total world bio-ethanol is produced in America, [9] the first generation of bio-ethanol was produced from natural crops such a cereal crops (wheat and maize), sugar cane, sweet sorghum and sugar beet, [10-11] while lingocellulosic biomass was the raw material for the second generation. The lignocelluloses materials include agricultural residues, municipal solid wastes (MSW), pulp mill refuse wood residue, switch grass and lawn, garden wastes. [12-13] No other sustainable option for production of transportation fuels can match ethanol made from lignocelluloses biomass with respect to its dramatic environmental, economic and infrastructure advantages. The potential of using lingocellulosic biomass for energy production is even more apparent when one realizes that it is the most abundant renewable organic component in the biosphere. It accounts for approximately 50% of the biomass in the world with an estimated annual production $10\text{-}50\times l0^{12}$kg. [14]

Recently, researchers have great interest on the production of ethanol by using biomass. The economic feasibility however has always, been focused towards improving the yield of ethanol production from biomass. Optimization of bio-ethanol production process from lignocelluloses can reduce energy consumption, environmental pollution and consequently increasing food availability. [15] All ethanol production is based upon the activity of yeast (*Saccharomyces cerevisiae*), an important microorganism to humans. Through a process called “fermentation,” yeast eats simple sugars and produce carbon (iv) oxide (CO2) and ethanol as waste products. [16]

In this study, Corncob was chosen because it consists of useful sugar and monomers of sugar that could be fermented to produce ethanol. Corncob is the central core of an ear of maize. It is the part of the ear on which the kernels grow. [17] It contains lignocelluloses and moisture and is the major waste from maize.

Corncob serves as a cheap substrate for ethanol production, does not distort the human food chain and takes care of the environmental waste. Acid hydrolysis is one of the pre-treatment methods used for the lignocelluloses contents to make it susceptible to fermentation to obtain ethanol dilute acid hydrolysis requires high temperature and pressure which makes it expensive and inhibit yield.

This present study focuses on optimizing ethanol production from the lignocelluloses content of corncobs using acid hydrolysis of varying acid concentration to produce fermentable sugar and the analysis of the yeast concentration on the yield of ethanol from fermentable sugar 'derivable from corresponding acid hydrolyzed lignocellulosic content is considered.

The aim of this research project is to improve the production of ethanol from corncob using acid hydrolysis method by converting cellulose into a smaller sugar using diluted sulphuric acid, comparing the yield of ethanol using different concentrations of acid to know the optimum field and determining the effect of yeast concentration on the production of ethanol.

2. Materials and Methods

2.1. Materials

Corncobs were the sample used for this experiment, corn cobs were collected in a polythene bag from a local market in Sokoto metropolis. The collected samples were washed, sundried, and crushed using mortar and pestle, after which they were grinded to obtain finer particles.

2.2. Method

2.2.1. Acid Hydrolysis

20g of corncob was added to a conical flask 0.4% H_2SO_4 was added and stirred thoroughly, 100cm3 of distilled water was placed in 500 cm^3 beaker and the acid sample mixture was transferred into the beaker of water. The acid sample water mixture was then autoclaved at 75°C for 60 minutes. The content was cooled and stored for 24 hours.

The pH was adjusted to a value between 5.0 and 6.0 (which is conducive for the yeast) by gradually adding drops of NaOH.

$$(C_6H_{10}O_5)n \rightarrow C_6H_{10}O_6$$

Lignocellulose→Glucose

The procedure was repeated for 0.6%, 0.8% and 1% H_2SO_4.

2.2.2. Fermentation of the Hydrolyzed Corncobs

This was carried out by warming 100cm^3 of each hydrolysate labelled accordingly in the conical flask, 1.5g of yeast was added to each of them. The conical flask was cotton lugged and covered with aluminium foil sheet to prevent oxygen from entering into the fermentation medium. They were all taken to the incubator for incubation at 37°C for seven (7) days.

2.2.3. Distillation

After the four (7) days of fermentation, the bio-ethanol was obtained by filtering each fermented mixture through a muslin cloth, and through a filter paper. 70cm^3 of each filtrate was distilled using the distillation apparatus for 30minutes. The distillation works by boiling the mixture between 78°C and 85°C. The bio-ethanol distillate was collected at the end of the distillation column.

2.2.4. Qualitative Test for Bio Ethanol

To determine the presence of ethanol in the distillate, 2 drops of 0.1M acidified $K_2Cr_2O_7$ was added to 2cm^3 of each distillate and heated for 30minutes in water bath. The appearance of green colour indicates the presence of ethanol.

$$K_2Cr_2O_7+H_2SO_4+2C_2H_5OH\xrightarrow{\Delta}2K_2SO_4+2Cr_2(SO_4)_3+3CH_3COOH+H_2$$

3. Results and Discussion

The results of the analysis carried are presented in the tables below.

Table 1. *Result of UV/visible spectrophotometer analysis of reducing sugar after acid hydrolysis at different concentration.*

Acid Conc. H_2SO_4	Absorbance (477nm)	Reducing Sugar Concentration (mg/m)
0.4 M	0.253	2.824
0.6 M	0.292	3.259
0.8 M	0.368	4.108
1 M	0.447	4.984

Table 2. *Result of physical parameters measured for each different concentration.*

Acid Conc. H_2SO_4	Volume (cm^3)	Density ($glcm^3$)	Percentage yield (%)
0.4 M	$8.4cm^3$	$1.0g/cm^3$	42%
0.6 M	$9.1cm^3$	$1.03 g/cm^3$	47%
0.8 M	$9.7cm^3$	$1.04 g/cm^3$	50.5%
1 M	$11.0 cm^3$	$1.02 g/cm^3$	55.5%

Table 1 show that the UV/visible spectrophotometer of 1M H_2SO_4 has the highest absorbance of 0.447 followed by 0.8 M (0.368), 0.6 M (0.292) and 04 M (0.253).

In table 2 the result obtained from the physical parameters measured for each different concentration after fermentation processes of the bio-ethanol produced, 1M H_2SO_4 of the corncobs prepared produced the highest percentage yield (55.5%) of the bio-ethanol followed by 0.8 M (50.5%), 0.6 M (47%) and 0.4 M produced the lowest percentage yield (42%).

4. Conclusion

This research work was based on the extraction of reducing sugar form corncob and subsequent fermentation of the sugar to ethanol. It can be concluded that acid hydrolysis at room temperature and atmosphere pressure can be used to improve the production of ethanol from the lignocelluloses content of corncob. The optimum condition for acid hydrolysis of lignocelluloses content of corncob to give maximum percentage yield occurs at a concentration of 1M H_2SO_4.

The potential ethanol yield from corn cob is $358cm^3/kg$, this suggest that ethanol yield obtained can be improved further. [18]

This work has clearly shown that acid hydrolysis at 1M H_2SO_4 with moderate yeast concentration $3g/20cm^3$ at room temperature and atmosphere pressure can be used to improve the production of bio ethanol. The other important aspect by deploying the bio-ethanol option is its benefit to the environment. Ethanol is one of the best tools to fight vehicular pollution; its clean burning reduces the harmful gasses and particulate emissions that pose health hazard. The implementation of bio-ethanol policy can be helpful in improving in environment and rural economic development with sustainable agricultural practices and enhancement of biomass feedstock conscious usage towards the bio-ethanol industry will bring up the new age farmer into the limelight and horizon of activities and threshold of business to become renewed with options to deal better in life.

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