International Journal of Recent Technology and Engineering (IJRTE)
ISSN: 2277-3878 (Online), Volume-8 Issue-6, March 2020

Production and Thermal Characterization of Ethanol Blends from Black Jaggery

Nitin Ralph Pochont, Vinay Atgur, K.M.V. Ravi Teja, G Manavendra, G.P. Desai, P. Vijaya Kumar

Abstract**: *To protect the environment from the global warming dependency on the fossil fuels have to be reduced. Locally available alternate fuels are greatly prominent for the development of industrialization compared to conventional fuels. This paper mainly deals with the production of Ethanol from a source called "Black Jaggery" and an Optimization of the extracted alcohol to attain the characteristics and properties which would be essential to blend the alcohol with an existing fossil fuel. Black Jaggery being a sugar-based product is fermented in the presence of a yeast enzyme for several days and is distilled to extract the bio-fuel (ethanol) from the source. The extracted oil is characterized for the thermal properties by using thermal constant analyzer TPS-500 which will be helpful for the combustion studies. Obtained results shows that compared to E-5, E-10 and E-20, E-15 blend shows better thermal properties increased thermal conductivity, thermal diffusivity with reduced specific heat.***

Keywords**: *Black Jaggery, Fermentation, Distillation, Thermal Conductivity, Specific heat and Thermal diffusivity.***

I. INTRODUCTION

As years pass by, the usage of fossil derived fuels is increasing tremendously and the demand to meet the usage is slowly degrading. And it is very clear that by the next ten to twenty years, the availability of such fossil fuels will be vanished. In order to meet the demand for fuel usage, science gave birth to something called Alternate fuel. Alternate fuels are the fuels derived apart from fossil fuel and they are mostly derived from renewable sources. Alternate fuels comprise mainly of Ethanol and Bio-diesel derived from Bio-wastes. Biofuels are considered as the most promising source for alternate fuels.

Biofuels such as Bio-diesel and Ethanol have gained importance since they have the tendency of blend and are used as the substitute for fossil oils. Bio-diesel is a fuel derived for sources which contain Lipids and is defined as mono-alkyl esters of long chain fatty acids derived for Vegetable oils or Animal fats. Bio-diesel is generally blended with diesel fuel to several proportions and is referred to as blend concentrations.

Bio-diesel contains no petroleum, but it can be blended with any level with petroleum diesel to create a biodiesel blend. Bio-diesel can be derived only from non-edible oils. The general process adopted among many for the production of bio-diesel is Transesterification.

Ethanol is an alternate fuel which can also be derived from Bio-wastes. Unlike Biodiesel, ethanol can be derived from sources which contain Starch or Carbohydrates. Ethanol or Ethyl-Alcohol (C_2H_5OH) is extracted only from sugar/starch containing sources by the process well known called Fermentation. Fermentation is a process in which the sugars/starch breakdown into acids, alcohol and gases and this takes place in the presence of enzymes which play a role in breaking down the sugars [1]. Since it is the fact that fermentation breaks the sugars into alcohols, ethanol is considered as one type of alcohol. In other word, ethanol can just be considered as alcohol. Generally, the enzyme used in the fermentation process is healthy yeast because it has good tendency to breakdown the sugars.

When ethanol is derived or produced from any biological source, then it achieves the name as Bioethanol. Ethanol or Ethyl-Alcohol is a colorless liquid, biodegradable, less in toxicity and has a very less environmental effect. Similar to biodiesel, even ethanol can be blended with an existing fossil fuel. Ethanol can be blended with Gasoline or Petrol and it is used in Spark Ignition engines. The production and usage of ethanol as blending fuel has gained its importance for the reason that ethanol reduces the emission of gases from the automobiles and thereby reducing the threat to the environment.

When ethanol first came into the picture, it was used to replace lead which is mixed with gasoline. Lead is added to gasoline or petrol to reduce the tendency of Knocking in the engine which is caused due to abnormal combustion and auto ignition. Ethanol has a very high octane number and it is a fact that fuels with high octane number has lower tendency towards knocking. Lead posed a threat to the environment by releasing poisonous gases such as carbon monoxide etc. Ethanol replaces lead and reduces the effect of knocking and also the emission.

Manuscript received on March 15, 2020.
Revised Manuscript received on March 24, 2020.
Manuscript published on March 30, 2020.
* Correspondence Author
Nitin Ralph Pochont*, Department of Mechanical Engineering, Koneru Lakshmaiah Education Foundation, Guntur, INDIA. Email: nitinralph@gmail.com
Vinay Atgur, Department of Mechanical Engineering, Koneru Lakshmaiah Education Foundation, Guntur, INDIA. Email: atgurvinay@gmail.com
K.M.V. Ravi Teja, Department of Mechanical Engineering, Koneru Lakshmaiah Education Foundation, Guntur, INDIA. Email: leo.raviteja@gmail.com
G Manavendra, Department of Mechanical Engineering, Koneru Lakshmaiah Education Foundation, Guntur, INDIA.
G.P. Desai, Department of Mechanical Engineering, Koneru Lakshmaiah Education Foundation, Guntur, INDIA.
P. Vijaya Kumar, Department of Mechanical Engineering, Koneru Lakshmaiah Education Foundation, Guntur, INDIA.

Crops having high starch/sugar content such as Corn, Maize, Sweet Sorghum, Wheat crops, Sugar cane and many more are grown purposely and are harvested to produce ethanol from them. Jaggery is a concentrated product of Sugar cane, Palmyra, Date without separation of the molasses and crystals [2]. Jaggery contains 50% of Sucrose, 20% of invert sugars, 20% of moisture and 10% of insoluble matter. Since jaggery has a major proportion of sucrose content in it, it is considered to be a good source to produce ethanol.

Among the different type of jaggery available, black jaggery is one type sugar cane product and it is mostly used to produce Arak (Drinking alcohol) and also used in the field of medicine [3].

In this study, black jaggery is taken as the source to produce ethanol. The black jaggery is fermented and distilled to produce ethanol.

An optimization has been done to evaluate the peak of ethanol produced from the source [4]. Several papers have been taken into consideration and the results have been compared.

II. MATERIALS AND METHODS:

Substrate:

Black Jaggery produced from sugar cane and was available at a local market.

Inoculum Preparation:

Baker's Yeast (*Saccharomyces cerevisae*) which is commercially available is used as an inoculum for the production of ethanol. It is revived in distilled water at 30ºC and grown on yeast extract potato dextrose (YEPD) agar. The morphological appearance is viewed under microscope and the pure culture was maintained in YEPD agar slants. (Yeast extract-10, Peptone-20, Glucose-100 and Agar-30 g/L respectively). During each fermentation experiment 8-hour old culture is used as inoculum by freshly growing it in YEPD broth at 30ºC.

Fermentation of Black jaggery:

At first, the black jaggery was dissolved in distilled water in a ratio of 1:3 to form a solution i.e. 100 grams of jaggery and 300ml of distilled water. Three different samples were prepared of the same substrate concentration. The pH of these samples was then adjusted to form Acidic (pH 4), Neutral (pH 7) and Basic (pH 10). This was done by adding small amounts of acid and base.

The three different pH's were considered to study the effect of pH on ethanol production and also to determine the optimum pH range i.e. acidic, neutral or basic favorable for the production of ethanol.

The samples were now ready and were stored in room temperature (30^0 to 34^0C) for a period of 8 days for the fermentation to take place in order to produce ethanol.

The fermentation process is one of the most commonly and widely used processes to convert carbohydrate into alcohol. This process can be catalysed by adding yeast enzymes [5]. The fermentation process involves the mixing of the sugar source, water and yeast and then allowing the yeast to act in the absence of oxygen.

Such an environment, stops the burning of sugar, instead results is the fermentation of alcohol.

Distillation of ethanol:

Distillation is a process to separate a mixture of liquids, oils, solutions, etc. This process is based on the different boiling points of the components involved in the mixture. The mixture whose components need to be separated is placed inside the distillation flask which is then heated. The component with the lower boiling point will vaporize first and then it passes through the distillation head into a condenser [6]. The vapors are cooled and liquefied within the condenser and the resultant liquid is collected in a receiving flask.

Ethanol is separated from the sample mixture by the simple distillation process as mentioned above. The boiling point of ethanol ranges between 50-60^0C. Therefore, by maintaining this temperature, the ethanol present in the mixture vaporizes and then passes into the condenser where it is liquefied and collected in the receiving flask.

Figure 1: Distillation setup to separate ethanol

III. CHARACTERIZATION OF ETHANOL

Ceric Ammonium Nitrate Test:

To 1 mL of the ceric ammonium reagent 4 to 5 drops of distillate is added and mixed thoroughly. Alcohols react with the reagent to form a red alkoxy cerium (IV) compound. If a red color develops, watch the solution carefully and note the time for the mixture to become colorless. If no change is noted in 15 min, the test tube may be stoppered and allowed to stand several hours or overnight.

Spectrophotometric method:

To 20 ml distillate, 25 ml of potassium dichromate solution ($K_2Cr_2O_7$) was added and the flasks were kept in a water bath maintained at 62.5ºC for 20 minutes. The flasks were cooled to room temperature. Five ml of this was diluted with 5ml of distilled water for measuring the optical density at 600nm using a spectrophotometer. A standard curve was prepared under similar set of conditions by using standard solution of ethanol containing 2 to 12% (v/v) ethanol in distilled water [7]. Ethanol content of each sample was estimated and graph was made.

Thermal Constant Analyzer:

Thermal Conductivity, Specific heat and Thermal diffusivity are determined by experimentally by using Hot Disk TPS 500 Thermal Constants Analyzer, Fig 2. TPS 500 measures the properties accurately and rapidly by using two sensors Kapton sensors-7577*, 5465, 5501 and Teflon sensors: 7577*, 5465, 5501.Temperature increased during the experimentation is around 4K.

Table 1. Thermo-physical Properties comparatively

	Petrol	E-5	E-10	E-15
Density @15.6c	0.7400	0.7385	0.7396	0.7495
API gravity (deg)	59.53	58.42	57.10	57.09

Kinematic viscosity mm^2/sec @30c	0.4872	0.4925	0.5383	0.5619
Flash point ©	–	–	–	–
Fire point ©	25.0	27	29.0	29.1
Cloud point ©	-22	>8	>8	>8
Head of combustion MJ/L	34.84	34.12	33.19	32.91
Octane number	93.2	95.2	97.1	98.6

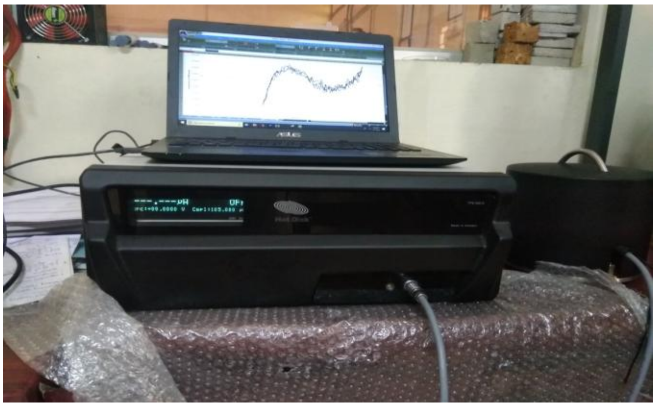

Figure-2: TPS 500 Thermal Constants Analyzer

IV. RESULTS AND DISCUSSION

Baker's yeast was used to ferment black jaggery to produce ethanol. Yeast helps in converting the carbohydrates into alcohol and carbon dioxide. The baker's yeast was grown on YEPD agar and the pure culture was sub cultured, which was used for fermentation process. The ethanol production was carried out by maintaining different pH (4, 7, and 10). Fig 3. shows the distillate obtained after distillation of the three different samples at different pH.

Figure 3: Ethanol obtained at different pH

The presence of ethanol was qualitatively analyzed using Ceric Ammonium Nitrate test. It was observed that the yellow color of the reagent changed into red, indicating the presence of ethanol [9]. The concentration of ethanol was estimated using spectrophotometric method. Fig 4 represents the standard graph for ethanol.

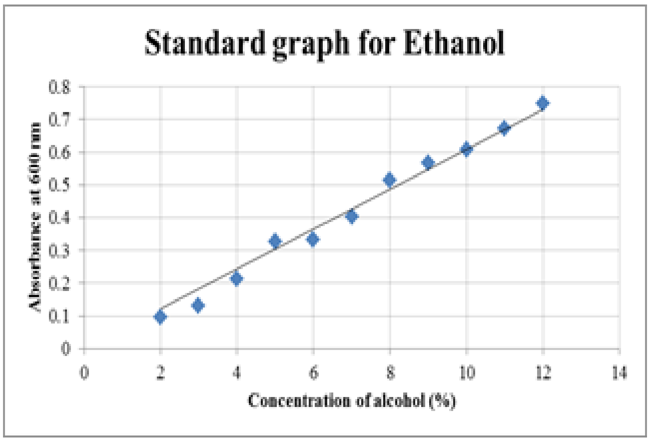

Figure-4: Standard graph for ethanol

The absorbance values for the three samples with different pH were estimated using Spectrophotometer [10]. Using the absorbance value, the concentration of the ethanol was calculated from the standard graph. The absorbance and concentration values for the three samples are shown in the table 2.

Table 2. Absorbance & Concentration values

pH	Absorbance at 600 (nm)	Concentration (%)
Acidic (4)	0.532	8.5
Neutral (7)	0.445	7.2
Basic (10)	0.08	1.12

Table 3. Comparison of Thermo-physical Properties

S. No	Sample	Thermal Conductivity, k (w/mK)	Thermal Diffusivity, α (mm^2/sec)	Specific Heat, Cp (MJ/m^3K)
1.	Ethanol	0.499	1.553	0.3219
2.	E-5	0.626	2.944	0.2133
3.	E-10	0.530	1.653	0.3240
4.	E-15	0.558	1.718	0.3249
5.	E-20	0.523	1.436	0.3286

It was observed that percentage of ethanol production was highest in pH 4 followed by pH 7 and very less amount of ethanol was produced in pH 10. Table.3 shows the variation of thermal conductivity, thermal diffusivity and specific heat values for Ethanol, E-5, E-10 and E-15 [11]. It is noted that as temperature increases thermal conductivity decreases for all the three ethanol blends. Since the FAME profile of E-15 indicates that there is more contain of oxygen compared to E-10 and E-5 it indicates better thermal conductivity [12]. Due to the presence of weaker double bonds both the ethanol-based samples exhibit better thermal properties compared to ethanol and petrol. For E-5 blend thermal properties are enhanced compared to petrol since ethanol is having high latent heat of vaporization, therefore the peak temperature raised for E5 is greater than petrol [13]. For E-10 blend we can observe that thermal properties are decreasing compared to E-5 due to the more content of ethanol which will be easily evaporated during the combustion phenomena [14].

For E10 the kinematic viscosity 0.5383mm2 per sec which is highest compare to petrol 0.4872mm2/sec. therefore E10 blend exhibits more specific heat and less thermal conductivity compared to remaining blends [15]. peak. E10 blend will be having more oxygen content compare to E5 and petrol, therefore combustion becomes better by increasing the thermal efficiency [16]. Since the octane number for E15 is around 98.6 when compare to E10, E5, petrol, 97.1, 95.2, 93.2 respectively, the increase in octane rating of the fuel by the addition of ethanol has been absorbed. The sense of the increased evaporating cooling brought by the blends is the key to the increased efficiency.

V. CONCLUSION

Thus, we can conclude black jaggery is one of the prominent sources of ethanol production and it concludes that the blending ethanol with gasoline is economical with reduced harmful pollutions because of the following reasons.

- Acidic pH is suitable for the production of ethanol from black jaggery.
- E-10 and E-15 blends exhibit better thermal properties which increases the thermal efficiency of the engine with reduced emissions.

REFERENCES

1. Neeru Gakkhar and Rashmy Nair, Production of Alcohol Through Fermentation in Saccharum Officinarum (Sugarcane) and Jaggery (Gur). International Journal of Recent Research and Review, Vol. 6, Issue 2, September 2013
2. B.V.V. Ratnam, S. Subba Rao and M. Damodar Rao, Optimization of medium constituents and fermentation conditions for the production of ethanol from palmyra jaggery using response surface methodology. World Journal of Microbiology & Biotechnology (2005) 21:399–404.
3. Mary Anupama.P, D.Guru Mahesh and C.Ayyanna, Optimization of Fermentation medium for the production of Ethanol from Jaggery using Box- Behnken Design. International Journal of Applied Biology and Pharmaceutical Technology, Volume: I: Issue-1 May-July -2010.
4. Mustafa Balat and Havva Balat, Recent trends in global production and utilization of bio-ethanol fuel. Applied Energy 86 (2009) 2273–2282.
5. Waleed Ahmad Khattak, Mazhar Ul-Islam and Muhammad Wajid Ullah, Yeast cell-free enzyme system for bio-ethanol productionat elevated temperatures. Process Biochemistry 49 (2014) 357–364.
6. Poonam Singh Nigam and Anoop Singh, Production of liquid biofuels from renewable resources. Progress in Energy and Combustion Science 37 (2011) 52-68
7. Anubhuti Gupta and Jay Prakash Verma, Sustainable bio-ethanol production from agro-residues: A review. Renewable and Sustainable Energy Reviews 41(2015) 550–567.
8. Thakur, A. K., Kaviti, A. K., Mehra, R., & Mer, K. K. S. (2017). Progress in performance analysis of ethanol-gasoline blends on SI engine. Renewable and Sustainable Energy Reviews, 69 (July 2016), 324–340.
9. Candeia, R. A., Freitas, J. C. O., Souza, M. A. F., Conceição, M. M., Santos, I. M. G., Soledade, L. E. B., & Souza, A. G. (2007). Thermal and rheological behavior of diesel and methanol biodiesel blends. Journal of Thermal Analysis and Calorimetry, 87(3), 653–656.
10. Deng, X., Chen, Z., Wang, X., Zhen, H., & Xie, R. (2018). Exhaust noise, performance and emission characteristics of spark ignition engine fueled with pure gasoline and hydrous ethanol gasoline blends. Case Studies in Thermal Engineering, 12 (October 2017), 55–63.
11. Chansauria, P & Mandloi, R. K. (2018). Effects of Ethanol Blends on Performance of Spark Ignition Engine-A Review. Materials Today: Proceedings, 5(2), 4066–4077.
12. Phuangwongtrakul, S., Wechsatol, W., Sethaput, T., Suktang, K., &Wongwises, S. (2016). Experimental study on sparking ignition engine performance for optimal mixing ratio of ethanol-gasoline blended fuels. Applied Thermal Engineering, 100, 869–879.
13. Dalla, M., Diórdinis, T., Lanzanova, M., & Zhao, H. (2018). Investigation of performance and combustion characteristics of a four-valve supercharged two-stroke DI engine fuelled with gasoline and ethanol. Fuel, 227 (May), 401–411.
14. Elfasakhany, A. (2015). Investigations on the effects of ethanol–methanol–gasoline blends in a spark-ignition engine: Performance and emissions analysis. Engineering Science and Technology, an International Journal, 18(4), 713–719.
15. Özcan, H., Özbey, M., &Gursel, O. (2018). The Effects of Ethanol-Gasoline, Methanol-Gasoline and Ethanol-Methanol-Gasoline Blends on Engine Performance, Combustion Characteristics, and Exhaust Emissions. The International Journal of Engineering and Science, Volume 7, Issue 6, Pages 70-82, 2018
16. Moulali, S., Rao, Y. V. H., Atgur, V., Manvendra, G., & Desai, G. P. (2020). Thermophysical properties of pongama honge oil methyl ester and rubber seed oil methyl ester for wide temperature range. International Journal of Vehicle Structures and Systems, 11(4), 452–455.

AUTHORS PROFILE

Nitin Ralph Pochont is an Assistant Professor – Department of Mechanical Engineering at Koneru Lakshmaiah Education Foundation, INDIA. He holds a Master's degree in the field of Energy and Environmental Engineering. He research is oriented towards Solar Energy, Biofuels and Automobile Engineering.

Vinay Atgur is an Assistant Professor – Department of Mechanical Engineering at Koneru Lakshmaiah Education Foundation, INDIA. He holds a Master's degree in the field of Thermal Engineering. He research is oriented towards Alternative Fuels and Fluid Dynamics.

K.M.V Ravi Teja is an Assistant Professor – Department of Mechanical Engineering at Koneru Lakshmaiah Education Foundation, INDIA. He holds a Master's degree in the field of Thermal Engineering. He research is oriented towards Alternative Fuels.