

Production of Biofuel from Banana waste

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ABSTRACT: BIOETHANOL IS CONSIDERED TO BE THE MOST OPTIMISTIC BIOFUEL. WITH THE INEVITABLE DEPLETION OF THE WORLD'S PETROLEUM supply, there has been an increasing interest in alternative, non-petroleum based sources of energy. A growing source of fuel worldwide is fermentation derived bioethanol. Bioethanol is produced from a wide variety of raw materials including corn starch, sugar cane and lignocellulosic waste materials like waste biomass from banana. The main cost element in bioethanol production is the feedstock. The work is carried out by using the waste banana biomass for the production of ethanol which provides more practical feasibility due to its low cost. Further distillation alone cannot concentrate ethanol beyond its azeotropic point, so various other methods are used to concentrate ethanol to completely anhydrous state in short span of 93-99.80% (w/w) ethanol. Among the separation methods, adsorption process is a simple and economical alternative. The water concentration in the feed solution was varied from 5% to 18% (weight basis). The potential of new Biobased adsorbents prepared from banana stem and central core was assessed in separation of ethanol-water mixture.

KEYWORDS: Bioethanol, lignocellulosic waste, banana pseudostem, central core.

I. INTRODUCTION

Worldwide Demand for ethanol production is increasing continuously due to rapid industrialization and growth in population. Conventional crop like sugar cane not able to meet the global demand of biofuel production due to primary value of food. The use of lignocellulosic biomasses has been considered an attractive alternative for the substitution of non renewable energy sources is reported by Dias et al., [1]; Fernandes et al., [2]; Sellin et al [3]. The agro industrial wastes stand out within these biomasses, due to their availability and low acquisition cost.

According to Souza et al [4], for each ton of banana fruit harvested around 4 tons of pseudostems remain at the harvest location undergoing natural degradation. Making use of this biomass for the production of alcohol for fuel could be a very attractive alternative by not only contributing to the preservation of the environment through removing this waste from the land. The advantage of utilizing agro industrial waste is abundant, renewable and cost effective. Bioethanol production from Banana Pseudostem waste could be promising technology through the process which is economic.

The actual work deals with the process bioconversion of cellulose from Banana Pseudostem waste, obtained from an Agro-industry, into ethanol by using the methods of acid pretreatment, hydrolysis and fermentation by *Aspergillus Niger*. Considering the value of the RS yield in the saccharification and the efficiency value in the fermentation process, it would be possible to obtain 187L of ethanol from each ton of dry biomass treated concluded by Souza et al [5]. Also the cheapest and easily available source for the production of bioethanol is fruit wastes. Janani et al., [6] studied comparison of the ethanol efficiency produced by fermentation process from different fruit wastes. The concentration of ethanol present in banana was 5.40% [7]. Talkad et al., [8] Obtained result for the *Saccharomyces cerevisiae* -EMS & UV Mutated, the Purity level for the Ethanol was found to be 73.5 % & 53.9 % respectively, with acid treatment it showed 53.9 %.

Ethanol purification is critical operation for any kind of purpose. For blending with gasoline ethanol to be used must be anhydrous since hydrated ethanol with more than 2% (v/v) water is not completely miscible with gasoline. Distillation can concentrate the ethanol up to azeotropic point but further dehydration technique adds costs to Bioethanol production. Adsorptive distillation is best among all separation techniques of ethanol dehydration. Molecular sieves used for dehydration purpose which require high temperature for regeneration so we should find

some alternative adsorbent for energy optimization. There is an incentive to find new cost effective biobased material sources for this application. Deposition of the biobased adsorbents is also environmental friendly as these are biodegradable reported by Benson and George [9]. Ability of starch and cellulose in selectively adsorption of water is a result of interaction in the form of hydrogen bonding between free hydroxyl groups (-OH) units and the water molecules given by K. Beery, and M. Ladisch [10]. In this work, new biobased adsorbents that are able to separate the azeotropic water-ethanol mixture are developed from banana waste. The water content in the feed solution varied and final ethanol the concentrations obtained.

II. METHODS AND MATERIALS

Bench-Scale Packed Bed Adsorption

The glass adsorption column with an inside diameter of 1.54 cm and a length of 35 cm was packed with 5 g of adsorbent. The column wall temperature was maintained constant at about 85°C by circulating hot water through the jacket. The temperature of the mixture in the boiling flask was measured constantly using thermocouple. Ethanol-water mixtures of 250 ml in each run with various water contents were used as starting solutions and were heated from a 500-ml flask surrounded by an electric heating mantle. The vapour was passed through the column, and the exit stream was condensed using cold water. The condensate was removed after every three minutes analysed for finding ethanol concentration. The average flow of the condensate was calculated for each run. The adsorbent was removed from the bed and dried for further use at the end of experiment. The adsorbents were efficient even after 5 cycles of the adsorption-drying process. The aqueous ethanol mixtures were prepared at four water levels, namely, 5.5 (the azeotropic concentration), and 12 wt%. The ethanol/water mixtures were blended using 200-proof ethanol and distilled water to make about 250 ml of solution as per required concentration at start of run. The time for completion of run depends upon the adsorbent and the feed composition.

Adsorbent Preparation

The raw banana stem fibers were washed with distilled water and then dried in an oven at temperatures of 70–80°C for 24 hours. The dried banana fibers were crushed and again dried. Further Banana stem fiber based adsorbents were prepared by pre-treatment. This pre-treatment include three stages mainly: dewaxing, alkali treatment and bleaching. Raw banana stem fibers were treated in Soxhlet extractor for removal of wax and oil in dewaxing process. The alkali treatment was done on dewaxed fibers for removal of unwanted alkali soluble material. Bleaching is done with sodium chlorite solution. After each above stages of pre-treatment amount of adsorbent dried in oven at 105°C for 20-30 min. Raw banana fibers, dewaxed fibers, alkali treated fibers and bleached fibers were used as adsorbents. Central core of banana is cut into small pieces then grind and dried in an oven at temperatures of 70–80°C for 24 hours and then used as adsorbent.

III. RESULT AND DISCUSSION

Biobased adsorbents were used to study the water sorption using two different water concentrations of ethanol-water mixtures. The results are examined for water contents of 5.5 and 18 wt%, respectively. The final concentration of ethanol in sample also can be calculated from the density data as shown in fig 1. It is seen that the time required to reach a plateau value varies as a function of the inlet water content of ethanol-water mixture. All the five adsorbents were compared and best among all is examined.

Table 1 and Table 2 show the variation in density of outlet ethanol samples collected with reference to time. Table 3 gives the data related to concentration of ethanol with various adsorbents. Ethanol Wt% can be calculated from fig 3 for respective density values obtained in Table 1 and Table 2. Specific gravity method used for density calculation

Table 1

| Time (min) | Density of outlet sample at 25 ^o C with various adsorbents | | | | |
|------------|---|----------------|-----------------------|-----------------|--------------|
| | Raw fibers | Dewaxed fibers | Alkali treated fibers | Bleached fibers | Central core |
| 0 | 0.8187 | 0.818699 | 0.818699 | 0.818699 | 0.8187 |
| 7 | 0.78723 | 0.787132 | 0.810451 | 0.80373 | 0.8188 |
| 10 | 0.78744 | 0.787336 | 0.809738 | 0.786216 | 0.81483 |
| 13 | 0.80454 | 0.797111 | 0.805563 | 0.786317 | 0.80974 |
| 16 | 0.80556 | 0.796704 | 0.800268 | 0.792834 | 0.80903 |
| 19 | 0.79813 | 0.794464 | 0.799962 | 0.792427 | 0.80363 |
| 22 | 0.79538 | 0.794158 | 0.793445 | 0.79202 | 0.79935 |
| 25 | 0.79436 | 0.792427 | 0.792427 | 0.791816 | 0.79915 |
| 28 | 0.78917 | 0.793038 | 0.803628 | 0.792834 | 0.80139 |
| 31 | 0.79406 | 0.793547 | 0.803832 | 0.792733 | 0.80129 |
| 33 | 0.79436 | 0.793445 | 0.803832 | 0.792733 | 0.80261 |

Table 2

| Time (min) | Density of outlet sample at 25 ^o C with various adsorbents | | | | |
|------------|---|----------------|-----------------------|-----------------|--------------|
| | Raw fibers | Dewaxed fibers | Alkali treated fibers | Bleached fibers | Central core |
| 0 | 0.801795 | 0.801795 | 0.8018 | 0.801795 | 0.801795 |
| 7 | 0.795482 | 0.795176 | 0.7963 | 0.796297 | 0.796297 |
| 10 | 0.795278 | 0.794871 | 0.79569 | 0.796093 | 0.795482 |
| 13 | 0.794566 | 0.79426 | 0.79518 | 0.795584 | 0.795075 |
| 16 | 0.793955 | 0.793751 | 0.79457 | 0.794566 | 0.794566 |
| 19 | 0.793547 | 0.793242 | 0.79375 | 0.793547 | 0.793547 |
| 22 | 0.792834 | 0.793038 | 0.79324 | 0.791511 | 0.79202 |
| 25 | 0.7909 | 0.791205 | 0.79161 | 0.791307 | 0.791409 |
| 28 | 0.791511 | 0.791409 | 0.79222 | 0.792325 | 0.792325 |
| 31 | 0.79314 | 0.793649 | 0.79253 | 0.792529 | 0.792733 |
| 33 | 0.793242 | 0.793445 | 0.79243 | 0.792427 | 0.792834 |

Table 3

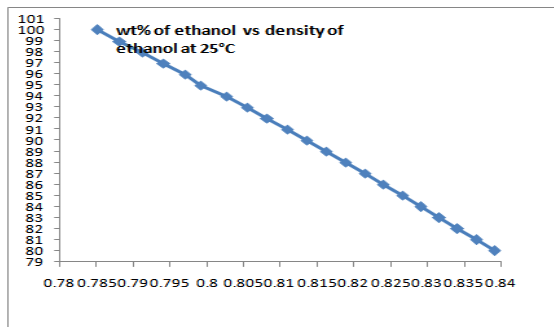


Fig 1.

| Adsorbents Used | Ethanol concentration | | | |
|-----------------------|-----------------------|-------|---------|-------|
| | Initial | Final | Initial | Final |
| Raw Fibers | 88 | 91.5 | 94.5 | 98.5 |
| Dewaxed Fibers | 88 | 92.2 | 94.5 | 97.5 |
| Alkali Treated Fibers | 88 | 93.5 | 94.5 | 96.7 |
| Bleached Fibers | 88 | 92 | 94.5 | 97.8 |
| Central Core | 88 | 94 | 94.5 | 97.6 |

IV. CONCLUSION

Ligno-cellulosic materials possess strong affinity towards water. Their hygroscopic nature allows for the uptake of water molecules from ethanol-water mixtures. It was found that these adsorbents were able to selectively adsorb and removed water from ethanol vapour. The effects of operating conditions including temperature, vapour feed concentration, type of adsorbent, and adsorbent particle size on the adsorption performance were examined. It is possible to obtain anhydrous alcohol, with ethanol concentration of 98.5 % wt from lower grade feeds containing 88 –95 wt % in this process. Among all the above adsorbents compared central core given maximum result for azeotropic mixture of ethanol, 94.5 wt%. This study elucidates that banana central core and banana stem fibers could be a raw material for preparation of adsorbent with target use of water adsorption. In conclusion, water adsorption with cellulose-based adsorbent could be an economical technique to produce anhydrous ethanol in country with large area of banana plantation.

REFERENCES

- [1] Dias, A., Toullec, J.L., Blandino, A., Ory, I., Caro, I. Pretreatment of Rice Hulls with Alkaline Peroxide to Enhance Enzyme Hydrolysis for Ethanol Production. *Chemical Engineering Transactions*, 32, 949-954.
- [2] Fernandes, E.R.K., Marangoni, C., Souza, O., Sellin, N., 2013. Thermochemical characterization of banana leaves as a potential energy source. *Energy Conversion and Management*, 75, 603-608, DOI:10.1016/j.enconman.2013.08.008
- [3] Sellin, N., Oliveira, B.G., Marangoni, C., Souza, O., Oliveira, P.N., Oliveira, T.M.N., 2013. Use of Banana Culture Waste to Produce Briquettes. *Chemical Engineering Transactions*, 32, 349-354, Somogyi, M., 1952. Notes on sugar determination. *Journal of Biological Chemistry*, 195, 19-23.
- [4] Souza, O., Federizzi, M., Coelho, B., Wagner, T.M., Wisbeck, E., 2010. Biodegradation of lignocellulosics residues generated in banana cultivation and its valorization for the production of biogas. *Revista Brasileira de Engenharia Agrícola e Ambiental*, 14, 4, 438-443
- [5] Elias L. Souza, Gean F. Lieblb, Cintia Marangoni, Noeli Sellin, Millena S. Montagnoli, Ozair Souza, 2014. Bioethanol from Fresh and Dried Banana Plant Pseudostem, *The Italian Association of Chemical Engineering*, VOL. 38, ISBN 978-88-95608-29-7; ISSN 2283-9216
- [6] Janani K., Ketzi M., Megavathi S., Dr. Vinothkumar D., Dr. Ramesh Babu N.G., 2013, Comparative Studies of Ethanol Production from Different Fruit Wastes Using *Saccharomyces cerevisiae*, *International Journal of Innovative Research in Science, Journal Engineering and Technology*, Vol. 2, Issue 12, ISSN: 2319-8753
- [7] S. Vaitheki & B. Deepa, 2016, A Comparative Study on the Production of Bioethanol from Individual and Mixed Fruit Wastes, *Imperial Journal of Interdisciplinary Research (IJIR)* Vol-2, Issue-5, ISSN: 2454-1362
- [8] Muralidhar Talkad, Chethan.C, Kavaya.S, Qudsiya.S.S, Aamir Javed, 2014, INDUCED MUTATIONAL STUDIES ON *SACCHAROMYCES CEREVISIAE* FOR BIOETHANOL PRODUCTION FROM FRUIT WASTE, *International Journal of Research in Engineering and Technology*, eISSN: 2319-1163 , pISSN: 2321-7308
- [9] Benson, T.J. and George, C. E. (2005), "Cellulose based adsorbent materials for the dehydration of ethanol using thermal swing adsorption," *Adsorption*, 11: 697-701.
- [10] Beery K., and M. Ladisch, "Adsorption of Water from Liquid-Phase Ethanol-Water Mixtures at Room Temperature Using Starch-Based Adsorbents," *Ind. Eng. Chem. Res.*, vol. 40, pp. 2112-2115, 2001