bagasse pith based biorefinery: a practical approach and valorization

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Abstract

Lignocellulosic ethanol programme has been initiated long back by various private as well as govt. agencies around the globe to relief any country's crude oil demand and thereby economic dependecy. Unlike biodiesel though ethanol has certain edges over other biofuels in terms of near drop in characteristics and technology maturation, but technol-economic feasibility still plays pivotal role to obstract its commercialization. High process cost in terms of feedstock procurement and depolymerization and upstream and downstream processing are major concerns of the Industries. It has been clearly understood that as a single product ethanol can not be landed inthe market, where it should be supported with array of value added products to reduce its cost and instead of a product lignocellulosic ethanol can only stand rather as a process in a biorefinery mode. CSIR-IIP started its ethanol programme with this concept and developed a process where a propeitory non sachcharomyces yeast Kluyeveromyces sp. IIPE453 *is used to grow on xylose rich pretreated lignocellulosic biomass hydrolysate and ferment glucose rich LCB broth at a near theroritical yield (88%) at high temperature (50^{o}C). Unutilized xylose stream is chanelized for calalytic conversion into furfural and leftover lignin rich biomass is gasified to generate producer gas or electricity. Overall process has been integrated with sensitivity analyses and economic feasibility study and we offer an end to end process for better utilization of bagasse or bagasse pith instead of co generation which can be integrated with a sugarmill or paper industry in a biorefinery mode.*

Keywords: *bagasse pith, biorefinery, Kluyveromyces* sp. IIPE453*, high temperature fermentation, furfural*

1. Introduction

Biorefinery concept is being experimented at pilot scale level at many parts of the globe targeting mainly lignocellulosic bioethanol. Production of ethanol from molasses and sugarcane juice is a more than hundred year old Industrial practice. Unfortunately produced ethanol as a tranportation fuel rises many questions which makes the product socio-economically unfeasible through out the globe. Though production of ethanol fromnon molasses feedstock such as grain,cssava, sugarcane juice is being practiced in many corners of the world,but its now evident that lignocellulosic ethanol can be only answer if world requires a contant suply of fuel ethanol. Bioethanol is one of the sole products other than biodiesel which is having a near drop in characteristics in terms of transportation biofuel. Lignocellulosic bioethanol can definitely reduce the burden of our country's crude oil import. CSIR-IIP started venture into 2nd generation bioethanol programme with an aim of developing an end to end process by complete utilization of sugarcane bagasse for ethanol production and further value addition [1-7]. Ultimate aim of lignocellulosic ethanol business is to reduce process and product cost which ethanol as a single product cannot resolve. Hence an array of value added products have been targeted to lower down ethanol cost. More over if the plant can be established along with a sugar mill or paper mill in line with biorefining concept transportation and supply of feed cost would be zero. With this background our lignocellulosic ethanol programme was integrated with CPPRI, Saharanpur, UP and a biorefinery concept was visualized where sugarcane bagasse pith (a waste generated by sugarcane bagasse based paper mills) was considered as feedstock. Presently paper industries use SCB pith as inefficient boiler fuel which has huge problem for disposal and environmental pollution. An average 300 tpd (Tonne per day) bagasse based paper mill consumes 800 tpd SCB and thus generates 160 tpd pith. Idea of establish a biorefinery at sugarmillor paper mill premises is to cater quick disposal of baggasse pith and thereby its value addition where there will not be any constraince for supply of feed from firm to factory. This work has been carried out integrate objectives like (1) Pretreatment and saccharification of lignocellulosic biomass; (2) Yeast biomass generation and further fermentation of biomass hydrolysate at high temperature and (3) Value addition to the process intermediates.

2. Materials and methodology

Lignocellulosic biomass (Sugarcane bagasse from local sugar industry and sugarcane bagasse pith from local paper mill) was subjected to steam and mild sulphuric acid pretreatment for recovery of xylose rich fraction and further enzymatic saccharification (market available cellulase enzyme) was optimized to recover hexose rich broth. CSIR-IIP bioethanol process is established with our own proprietary microorganism *Kluyveromyces* sp. IIPE453 (MTCC 5314), thermotolerant yeast [Fig 1], which grows and ferment at high temperature (50°C) and unlike *Saccharomyces cereviecae*, it can utilize pentose for cell biomass generation. High temperature growth and fermentation minimize the cost required for cooling of saccharified broth as well as chance of bacterial contamination.and also increase the rate of sugar uptake during growth and fermentation.

Excess pentose after obtaining growth of sufficient yeast cell is channelized for catalytic conversion for furfural production. Leftover lignocellulosic biomass which is rich in lignin is either gasified to generate producer gas or considered for even further valorisation in terms of lignin purity [Fig: 2].

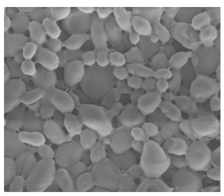

Fig 1: SEM of *Kluyeveromyces* sp. IIPE453 (MTCC 5314)

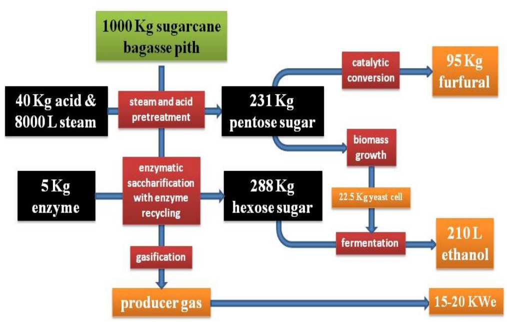

Fig 2: 2nd generation bioethanol and value addition of process intermediates with material balance

3. Results and Discussion

Sugarcane bagasse pith was optized for steam and dilute acid pretreatment and further enzymatic sachcharification to extract more than 95% xylose and 80% glucose. IIPE453 has been adapted to grow on xylose rich stream with $Y_{x/S}$ ~ 0.32 and readily ferment glucose rich stream with 88% conversion in terms of theoritical yield [12]. Yeast biomass generated on pentose stream can be recycled at least thrice and hence pentose stream was diverted for catalytic conversion for furfural with 40% conversion efficiency. Unlike conventional furfural production process with homogeneous acid catalysts, CSIR-IIP furfural process is based on heterogenous catalyst in a biphasic system which inturn facilitates easy product recovery [4, 8 – 11]. Lignin rich leftover biomass after enzymatic sachcharification was gasified to produce clean energy in form of producer gas [4] or even could be converted to electricity [Fig 3 & 4].

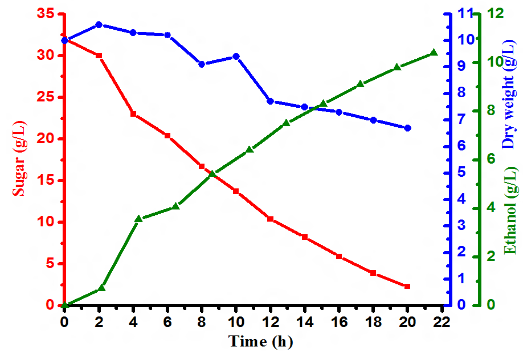

Fig 3: Ethanol production in batch mode by *Klyuveromyces* sp. IIPE453 in sugarcane bagasse hydrolysate at 50°C

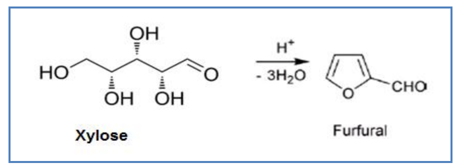

Fig 4: One step conversion process of xylose to furfural

4. Conclusions

Overall process has been integrated with sensitivity analyses and economic feasibility study and we offer an end to end process for better utilization of bagasse or bagasse pith instead of co generation which can be integrated with a sugarmill or paper industry in a biorefinery mode to obtain high value products such as furfural, value added lignin products, electricity apart from ethanol [4].

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