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Effect of Pretreatment of Rice Husk for the Production of Biogas

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Abstract: *Lignocelluloses are often major components of various industrial, forestry, agricultural and municipal wastes. Hydrolysis of lignocellulose is the first and required step for its digestion to biogas (methane). In the present study, efforts were made for the chemical hydrolysis of lignocelluloses in acidic, alkaline and neutral medium and the pretreated rice husk was digested in anaerobic medium for the production of biogas. Without pretreatment, rice husk produced 64% methane on anaerobic digestion which could be increased to an appreciable extent after delignification. All the methods adopted for delignification proved to be good however30% sulfuric acid was found to be most effective for delignification process leading to the production of 76% methane.*

Keywords: *Lignocelluloses, Pretreatment, Delignification, Enzymatic hydrolysis*

1. Introduction

Bio energy is a critical part of renewable energy solution to today's energy crisis that threatens world economic growth. The use of lignocellulosic feed stocks for bio fuels has gained much interest in the last few decades as they have huge potential for the production of bio energy. Lignocellulosic biomass is mainly composed of cellulose, hemi cellulose and lignin. Cellulose and hemi cellulose are a potential source of fermentable sugars for the production of biogas. Complete process of converting lingo cellulosic biomass to bio energy usually requires two steps: first a pretreatment in which lignin is removed, followed by the anaerobic digestion of cellulose and hemi cellulose to biogas. Biogas is an energy source that is used for the production of heat and electricity or as fuel in car in different countries (Sims, 2003; Ghosh et al., 2000).Pretreatment is effective not only in dissolving lignin, but it can also disrupt lignin and increases the cellulose's susceptibility to enzymatic hydrolysis (Wyman, 1996; Yang and Wyman, 2004).

Typical lignocellulosic biomass contain lignin (15–25% w/w), hemi cellulose (23–32%), and cellulose (38–50%)(Mamman et al., 2008). Cellulose is a glucan biopolymer containing glucopyranose subunits with a molecular formula of $(C_6H_{10}O_5)_n$, each subunit of which gains one H_2O molecule on hydrolysis. Thus, the maximum theoretical glucose yield for 100 g pure cellulose is 111 g. The glucopyranose subunits in the cellulose are linked by β-1,4-glycosidic bonds that are highly resistant to hydrolysis, mainly due to crystallinity of cellulose and the protective sheath of lignin and hemi cellulose that is wrapped around cellulose (Laureano-Perez et al., 2005). An effective pretreatment method can weaken all these hindrances and exposes cellulose to cellulase enzymes for effective hydrolysis (Fig.1). Alizadeh et al. (2005) reported that only less than 20% glucose is released from lignocellulosic biomass without pretreatment while the yield can beas high as 90% with proper pretreatment.

Many pretreatment methods have been proposed for lingo cellulosic biomass including mechanical, biological, chemical, steam explosion pretreatment and others (Zheng et al., 1995; Teymouri et al., 2004; Lloyd and Wyman, 1967; Mosier et al., 2005; Kim and Lee, 2007; Hendriks and Zeeman, 2009; Wan and Li, 2010; Karunanithy and Muthukumarappan, 2011; Narayanaswamy et al., 2011; Wang et al. 2012).

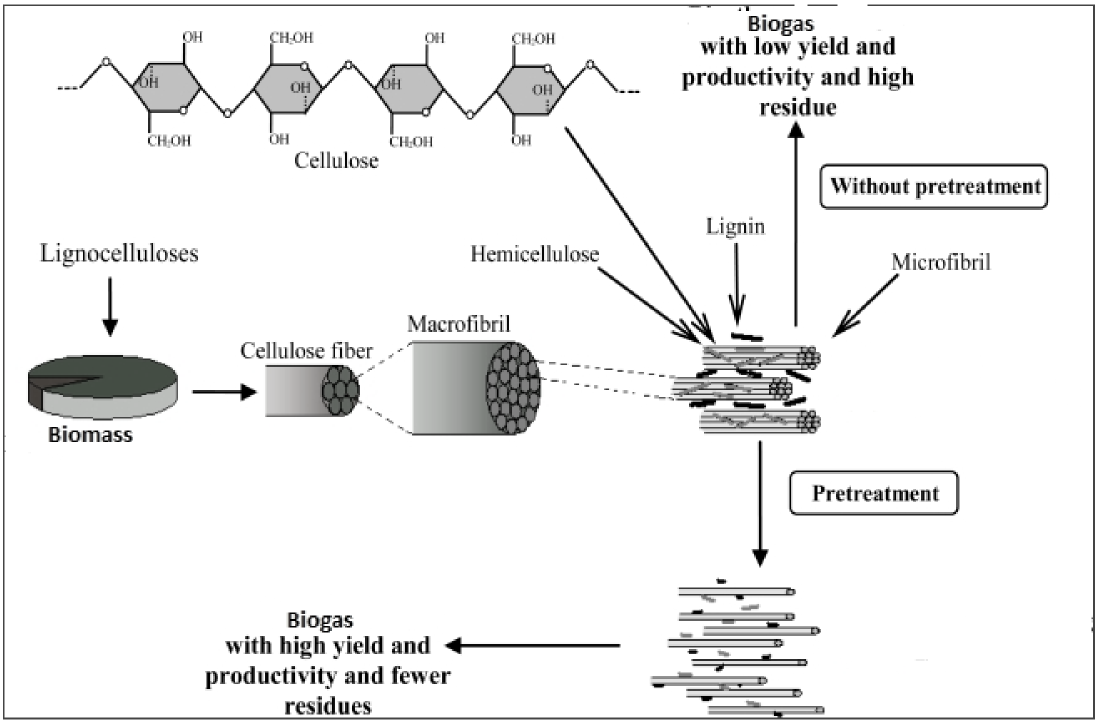

Fig1. *Effect of delignification on biogas production (Taherzadeh and Karimi, 2008)*

The breakdown of biomass in pretreatment facilitates hydrolysis by disrupting cell wall structures, driving lignin into solution or modification of the lignin structure, and reducing cellulose crystallinity and chain length, while preventing hydrolysis of cellulose. The nature and extent of such changes are highly dependent on the pretreatment chemistry, reaction severity and also on the nature of the biomass.

In the present study, acid, alkali and thermal methods of pretreatment have been used for rice husk and then treated biomass was used for its conversion to biogas via anaerobic digestion in batch stirred tank batch type reactor which further followed by its analysis by gas chromatography.

2. MATERIAL AND METHODS

Rice husk was collected from Dehradun (India). All the chemicals used (conc. sulphuric acid, sodium hydroxide and distilled water) were from Rankem and a standard lignin used was from Merck. Standard biogas sample were from Centurion scientific. Standard lignin samples of 1 and 10 ppm were prepared by dissolving weighed quantity of pure lignin (Rankem) in appropriate volume of distilled water.

3. EXPERIMENTAL

3.1. Pretreatment of Rice husk

Pretreatment of rice husk for the removal of lignocellulose was done by acid (variable concentrations of H_2SO_4 (Alizadeh et al., 2005) in an autoclave for 1hour at 121°C and 15 psi pressure), alkaline (1 and 2% solutions of NaOH for various time periods in autoclave at 121°C and 15 psi) and thermal methods (in neutral medium at different time periods in autoclave at

121°C and 15 psi). After each pretreatment, the solution was filtered and the filtrate was studied under UV-Visible spectrophotometer at 205 nm.

3.2. Production of Biogas

Rice husk before and after pretreatment (with either of above methods) was subjected to batch type bio-reactor (RPM 200, temperature 37°C, pH 6.5, HRT 36 hours) for biogas production (Fig. 2) separately. Gas was collected in biogas balloon via gas nozzle of digester and analyzed on gas chromatograph (GC Nucon -5700) sampler injector with injection syringe (injection volume 100µl, mobile phase argon, column stainless steel, column ID- HEYSEP.Q, run time 10 minutes).

Fig2. *Batch type Stirrer Tank Bioreactor*

4. Results and Discussion

Extent of delignification of rice husk in various media is given in Figures3&4.

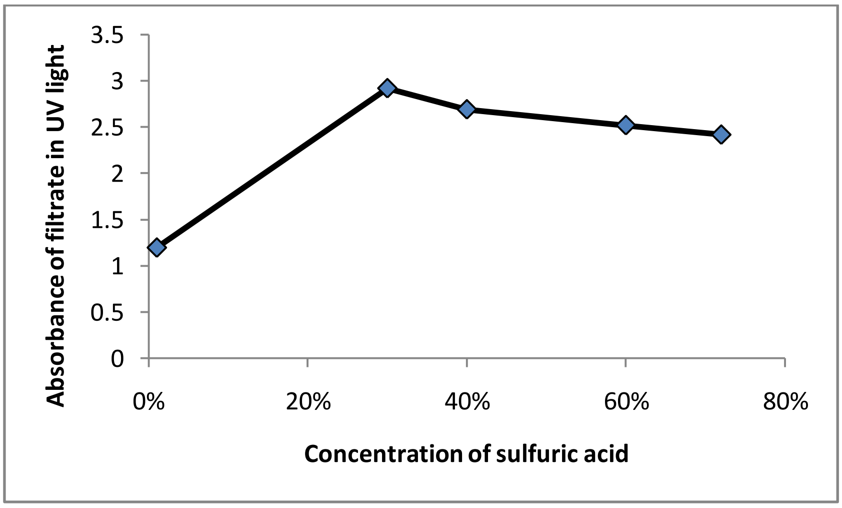

Fig3. *Effect of acid treatment on delignification*

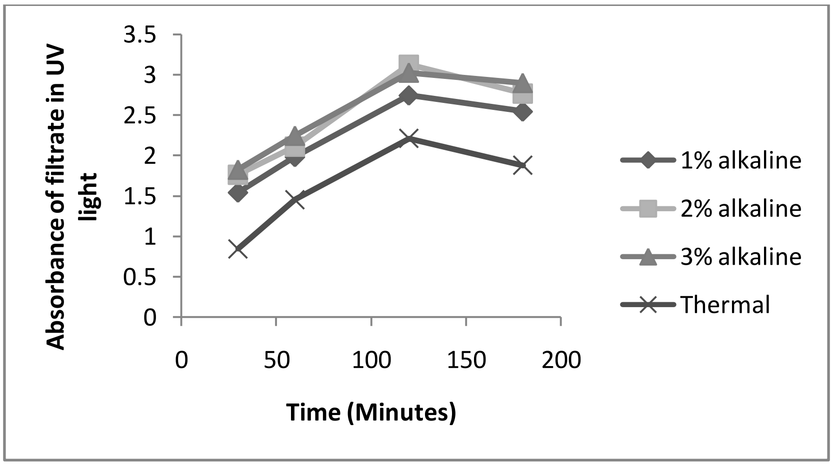

Fig4. *Effect of alkaline & thermal treatments on delignification*

Results indicate that maximum lignin content was able to be removed on reacting with 30% sulfuric acid (acid treatment),2% sodium hydroxide (alkaline treatment) for 2 hours (thermal treatment). Hydrolysis in various media was responsible for the considerable removal of lignin from rice husk. Pretreated biomass under different conditions was subjected to anaerobic digestion for converting it to biogas (Figure 5).

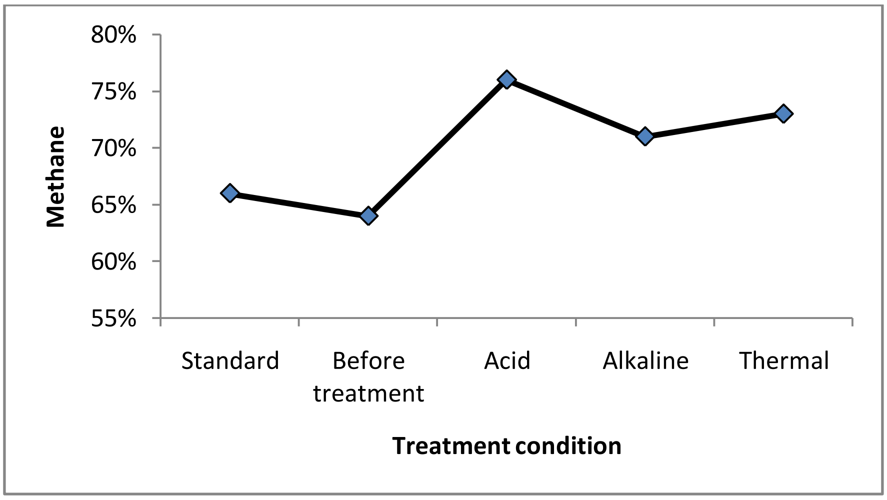

Fig5. *Biogas produced under different conditions*

Results show that before pretreatment only 64% methane was produced by the digestion of rice husk, which increased to 76, 71 and 73% in case of digestion of pretreated rice husk in acidic, alkaline and thermal medium, respectively. Increase in the amount of biogas produced is due to the rupture of lignin content present in rice husk, making cellulose available for easy digestion.

5. Conclusion

Pretreatment of biomass for the removal of lignin is an appropriate approach for the maximum usage of digestible contents present in it for its conversion to biogas. Various methods have been used for delignification and proved to be good in terms of biogas production. Maximum lignin was removed by acidic delignification process leading to the production of 76% methane. Alkaline delignification followed by digestion could result in the production of 71% methane whereas thermal treatment resulted in 73% methane.

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