A Technical Review Paper on Pretreatment of feedstock for enhanced biofuel production

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Abstract- **The efficient enzymatic conversion of cellulosic biomass depends heavily on the effectiveness of the pretreatment step. During pretreatment, the impeding layers (usually lignin and hemicellulose) in the biomass are removed or disrupted, and the cellulose becomes easily accessible to enzymes. A variety of pretreatment methods have been developed, differing significantly from one another in terms of reaction conditions, process efficiency and complexity, and impact on subsequent enzyme and microbial processes. This review presents the pretreatment techniques to enhance the anaerobic digestion of organic solid waste, including mechanical, thermal, chemical and biological methods. The effects of various pretreatment methods are discussed independently and results of some pretreatment are discuss from research work.**

Index Terms- **biomass, biofuel, pretreatment, anaerobic digestion.**

1. INTRODUCTION

Anaerobic digestion (AD) is a well-established process for renewable energy production in which biomass (also referred to here as substrate or feedstock) is broken down and converted to biogas (a mixture of methane, carbon dioxide and traces of other gases) by microorganisms. Commonly used substrates for biogas production include industrial waste such as dairy waste, agricultural waste such as fodder residue and manure, and energy crops such as maize (corn). The ability to make biogas out of many different substrates is one of the main advantages of anaerobic digestion over other processes like ethanol production. However, some substrates can be very slow to break down because:

- They contain chemicals that inhibit the growth and activity of the micro-organisms.
- They create physical problems like floating, foaming or clumping, and block impellors and pipes in biogas plants, or
- Their molecular structure is poorly accessible to microorganisms and their enzymes.

Sometimes all these problems occur at once. Pretreatment can be used to overcome some of these problems. The breakdown of cellulose and hemicellulose is further complicated by the bonds between different cellulose chains and by the presence of lignin, another polymer which slows down the breakdown process. It is generally believed that lignin cannot be degraded by anaerobic bacteria, although this has been challenged, and may even inhibit the degradation of other substances like cellulose Pectin also affects breakdown, binding cellulose fibrils together and binding plant cells together . Breaking down this lignocellulose complex is the key to biogas production . Various pretreatment technologies have been developed in recent years to increase the availability for AD of sugars and other small molecules in biogas substrates, particularly in lignocellulosic material.

The pretreatment process have following aims: make AD faster, potentially increase biogas yield, reduction of the retention time, better economical feasibility, make use of new and/or locally available substrates, prevent processing problems such as high electricity requirements for mixing or the formation of floating layers.

Different principal and techniques are used for pretreatment of biomass are listed in table 1.1

Principle	Techniques
Physical	Mechanical
	Thermal
	Ultrasound
	Electrochemical
Chemical	Alkali
	Acid
Biological	Microbiological
	Enzymatic

2. PHYSICAL PRETREATMENT

Mechanical pretreatment is carried out by mills and either makes the pieces of substrate smaller or squeezes them to break open the cellular structure, increasing the specific surface area of the biomass. This gives greater possibility for enzymatic attack, which is particularly important for lignocellulosic substrates. Menind and Normak (2010) used dried hay from different sources (including from a nature reserve where the hay was harvested once a year) and milled with a laboratory knife mill. They found an approximately 10% higher gas yield was achieved after knife milling hay to 0.5 mm compared to 20 to 30 mm. In pure thermal pretreatment, the substrate is heated (typically 125 to190 C) under pressure and held at that temperature for up to one hour.

Chen WH et al (2011) find that after biomass is torrefied, a portion of hemicellulose is removed and the cell wallin biomass is destroyed. Figure 2.1 shows scanning electron microscope (SEM) images of Cryptomeria japonica before and after torrefaction (at 300 for 1 h). There are many inclusions in the thick-walled fibers of C. japonica, and after undergoing nonoxidative torrefaction the number of these is significantly reduced, as clearly seen by the cell structures. This change in the microstructure improves the grindability of the torrefied biomass, which leads to an increase in the weight percentages of fine particles at the same grinding conditions, and also reduces the amount of energy that needs to be consumed to grind the biomass.

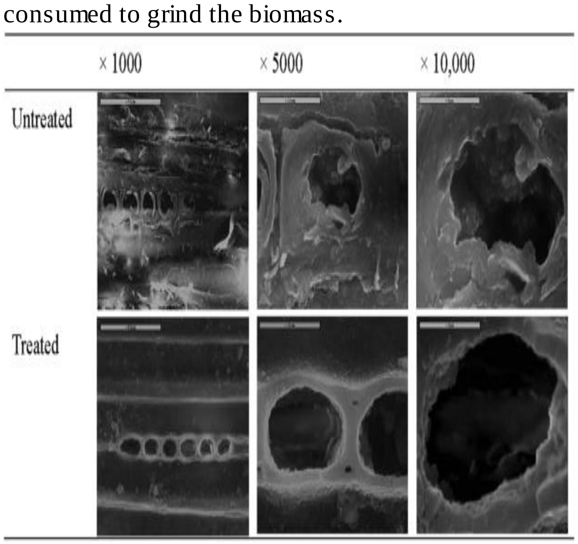

Figure 2.1: SEM images of Cryptomeria japonica before and after torrefaction

3. CHEMICAL PRETREATMENT

The common alkalis used for pretreatment of lignocellulosic biomass are NaOH, KOH, NH3, and Ca (OH)2. The cheapest alkali commonly used for pretreatment is Ca (OH)2, which removes lignin and acetyl groups that in turn increase the rate of enzymatic saccharification. Janu et al. reported morphological and physicochemical changes of NaOH pretreated sugarcane bagasse by SEM, XRD, and FTIR. Scanning electron micrographs revealed differences between the native and pretreated samples (Figure 3.1). Native samples exhibited a rigid, highly compact, and nonporous structure, while the pretreated samples showed an increase in porosity and greater surface area. With alkaline pretreatment, there is 82% reduction in lignin content.

The structural modifications of native and pretreated biomass were analyzed using FTIR spectroscopy. FTIR spectra of lignocellulosic materials were influenced by three main polymers cellulose, hemicelluloses and lignin. FTIR spectra of native and alkali pretreated sugarcane tops showed difference in the absorption spectra (Figure 3.2). The

carbonyl band at 1735/cm was weakened on pretreated sugarcane bagasse indicating removal of hemicellulose. The peaks corresponding to aromatic ring stretch at 1590/cm also were weakened indicating delignification.

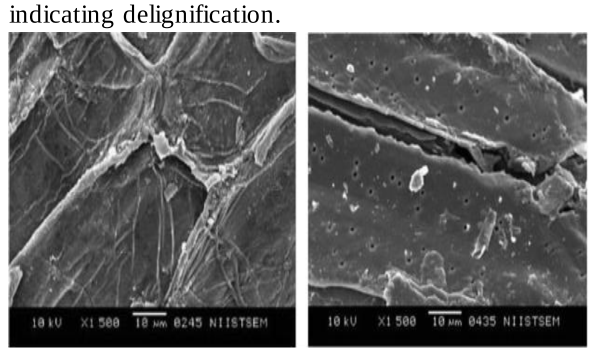

Figure 3.2: Scanning electron micrographs of native and pretreated sugarcane bagasse.

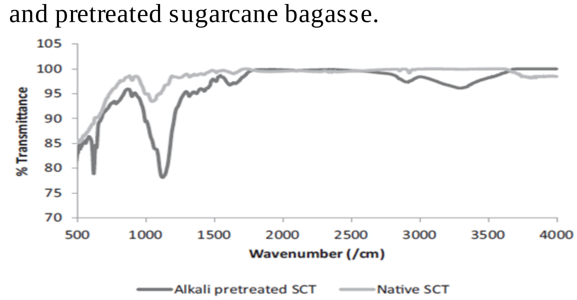

Figure 3.2: FTIR spectrum of native and alkali pretreated sugarcane tops.

Salma A. Iqbal et al conducted to investigate the production ability of biogas as an alternative energy from KW with co-digestion of cow manure (CM) through anaerobic digestion (AD). Three alkali (NaOH) doses 1.0%, 1.5% and .0% on wet matter basis of kitchen waste were applied to improve biodegradability and biogas production. The highest degradation rate was 6.8 ml/gm which was obtained from 1.5% NaOH and also observed that biogas production was almost doubled from treated KW than untreated KW.

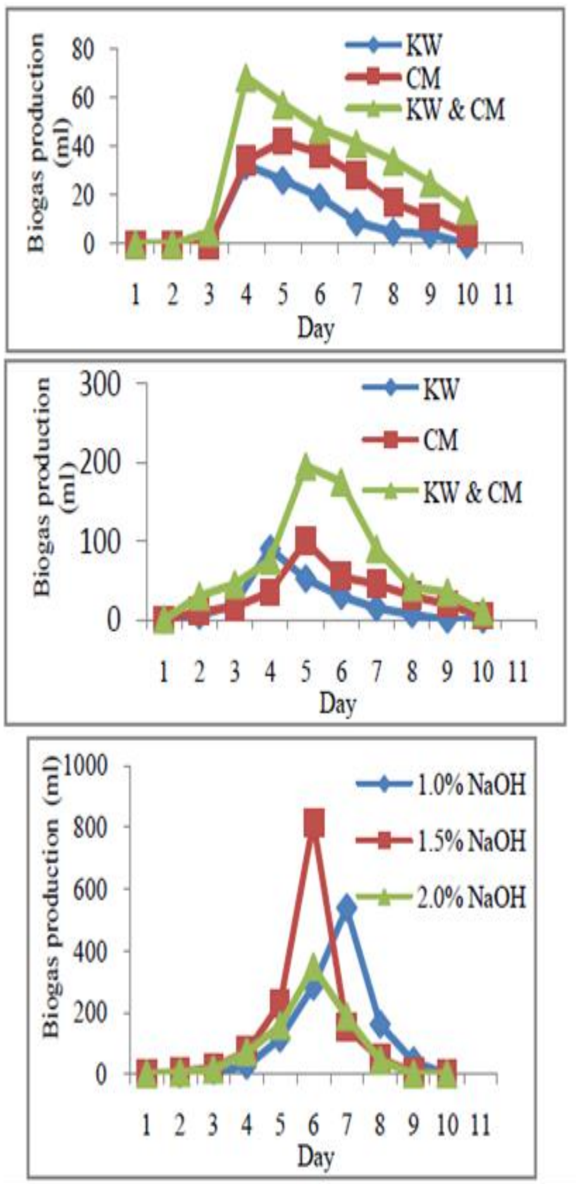

Figure 3.3: Effect of Sodium hydroxide (NaOH) on Methan production for KW

4. CONCLUSIONS

There are less work done to enhance the rate of production from biomass through various pretreatment processes but concrete research work required for biomass fuel throughout the country should be given priority in solving our energy crisis. Mechanical and Chemical treatment are the more convenient, it can be used for any feed stock for ameliorate biomass properties, due to pretreatment process we can work on new feed stock of biomass. Alkali pretreatment reduce the lignin content, new chemical can be used for the different feed stock for better result for that FTIR analysis and biogas production are key parameters.

REFERENCES

[1] Parameswaran Binod, Ashok Pandey,Pretreatment of Biomass: Processes and technologies, 1st Edition,Elsevier, 2014.

[2] www.iea-biogas.net/Pretreatment of feedstock for enhanced biogas production.

[3] http://www.btgworld.com/en/rtd/technologies/torrefaction.

[4] Fayyaz Ali Shah,Qaisar Mahmood,Naim Rashid,Arshid Pervez,Iftikhar Ahmad Raja,Mohammad Maroof Shah, "Co-digestion,pretreatmentanddigesterdesignfor enhanced methanogenesis", Renewable and Sustainable Energy Reviews, 42 (2015),627-642.

[5] Javkhlan Ariunbaatar,Antonio Panico,Giovanni Esposito,Francesco Pirozzi,Piet N.L. Lens "Pretreatment methods to enhance anaerobic digestion of organic solid waste", Applied Energy, 123(2014), 143-153.

[6] Jia Zhao, Yi Zheng , Yebo Li,"Fungal pretreatment of yard trimmings for enhancement of methane yield from solid-state anaerobic digestion",Bioresource Technology, 156 (2014),202 - 208.

[7] Rudianto Amirta, Elisa Herawati, Wiwin Suwinarti,Takashi Watanabe, "Two-steps Utilization of ShoreaWoodWaste Biomass for The Production of Oyster Mushroom and Biogas - A zero waste approach", Agriculture and Agricultural Science Procedia, 19 (2016), 149-153.

[8] Salma A. Iqbal, Shahinur Rahaman, Mizanur Rahman, Abu Yousuf, "Anaerobic digestionof kitchen waste to produce biogas", Procedia Engineering, 90 (2014),657- 662.

[9] Chen WH, Hsu HC, Lu KM, Lee WC, Lin DC. Thermal pretreatment of wood (Lauan) block by torrefaction and its influence on the properties of the biomass. Energy 2011;36:3012e21.