DETERMINATION OF COMPOSITION OF CELLULOSE AND LIGNIN MIXTURES USING THERMO GRAVIMETRIC ANALYSIS (TGA)

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ABSTRACT

The proportional composition of cellulose, hemicellulose, lignin and minerals in a biomass plays a significant role in the proportion of pyrolysis products (bio-oil, char, and gases). Traditionally, the composition of biomass is chemically determined, which is a time consuming process. This paper presents the results of a preliminary investigation of a method using thermo-gravimetric analysis for predicting the fraction of cellulose and lignin in lignin-cellulose mixtures. The concept is based on a newly developed theory of Pyrolytic Unit Thermographs (PUT). The Pyrolytic Unit Thermograph (PUT) is a thermograph showing rate of change of biomass weight with respect to temperature for a unit weight loss. These PUTs were used as input for two predictive mathematical procedures that minimize noise to predict the fractional composition in unknown lignin-cellulose mixtures. The first model used linear correlations between cellulose/lignin content and peak decomposition rate while the second method used a system of linear equations. Results showed that both models predicted the composition of lignin-cellulose mixture within 7 to 18% of measured value. The promising results of this preliminary study will certainly motivate further refinement of this method through advanced research

Keywords: TGA, Biomass, Biofuel, Bioenergy, Cellulose, Lignin, Composition

NOMENCLATURE

A	Empirical constant
$\left[(dw/dt)_b\right]_C$	Correlated derivative weight loss
$\left[(dw/dt)_b\right]_E$	Experimental derivative weight loss
$(dw/dt)_c$	Derivative weight loss of cellulose
$(dw/dt)_h$	Derivative weight loss of hemicellulose
$(dw/dt)_l$	Derivative weight loss of lignin
$(dw/dt)_e$	Derivative weight loss of extractives
n_1	Empirical constant
n_2	Empirical constant
X_c	Initial fraction of cellulose in a biomass
X_h	Initial fraction of hemicellulose in a biomass
X_l,	Initial fraction of lignin in a biomass
X_e	Initial fraction of extractives in a biomass
X_a	Initial fraction of silica free ash in a biomass
X_{si}	Initial fraction of silica in a biomass

INTRODUCTION

Recently, research on energy production from renewable resources like biomass and organic waste has gained tremendous momentum in the scientific community and the industrial sector. The United States Departments of Energy and Agriculture (DOE and USDA) are strongly committed to expanding the role of biomass as an energy source and envision a 30 percent replacement of the current U. S. petroleum consumption with biofuels by 2030 [1]. Accomplishing this target will require one billion dry tons of biomass feed stock per year. It is estimated that more than 1.3 billion dry tons of biomass can be obtained from forest and agricultural resources for energy production. The state of Georgia has more than 18million dry tons of forestry biomass material annually available for energy production, which includes unused wood resources, harvesting residues, mill residues, urban wood waste, pecan shells, paper mill sludge, and black liquor solids [2]. Biological and thermal pathways are generally used for energy production from biomass. Biological pathways are limited to high starch/sugar content material, whereas thermal pathways work for all types of biomasses.

Co-firing, direct combustion, gasification, and pyrolysis are the known thermal options available for extracting energy from biomass [3-4-5-6-7]. The thermodynamics and kinetics of a thermal decomposition pyrolysis process for any biomass depend upon the fuel's composition and pyrolytic conditions [8-9-10]. Knowing the makeup of the biomass material enables the processor to use the most effective and efficient thermal process including pretreatment and process conditions