# CHAPTER 1 INTRODUCTION

## 1.1 Background

Due to increasing fuel costs, renewable energy sources are gradually becoming a worldwide alternative to the non-renewable. Bioethanol is an interesting alternative because it is produced from agro-industrial wastes that is both a renewable material and environmentally friendly. Moreover, products created from renewable resources, especially biodegradable polymers are especially attractive nowadays. Usually, the plastic polymer, which is used to create consumer goods, is produced from the petrochemical sources obtained from crude oil distillation. However, the price of raw materials and energy consumption is the main obstacle for production as well as the current state of environmentally friendly product campaigning. Hence, production of a plastic polymer from renewable resources is the alternative way for polymer production. The succinic acid, lactic acid and butyric acid etc. are the chemical building blocks that are used as the feed stock to produce the biodegradable polymer. These acids are produced from the fermentation of monomeric sugar product, especially glucose. The strategy for producing these acids and ethanol are similar because these products are produced following more or less the same pretreatment, hydrolysis and fermentation steps; moreover, these products use the agro- industrial wastes as the feed stock. Corn is a raw material widely used for ethanol biofuel production. However, the cost of raw materials is expensive and the use of corn has effects on the food supply chain. So, the lignocellulose materials consisted of carbohydrate polymer (cellulose, hemicellulose) and aromatic polymer (lignin) will be used to the feed stock for ethanol fermentation. There are several types of lignocellulose used to produce ethanol such as sugarcane bagasse, sweet sorghum, sawdust and wood chips etc. [6]. For Thailand, sugarcane bagasse is the most attractive raw material that is used to produce bioethanol because it has a tropical climate that favors agriculture enabling a very positive climate for corn fields to grow plentifully.

In general, ethanol and special acids are produced from enzymatic fermentation. However, the pretreatment method is the most important step to improve the effectiveness of fermentation by the removing of lignin. Lignin is the a complex chemical compound that form a protective shield around cellulose and hemicellulose and protecting polysaccharide from enzymatic degradation to covert cellulose to sugar [17]. Although hemicellulose rarely causes the problem of hydrolysis, it can be removed by using dilute acid pretreatment to convert to sugar monomer such as xylose, D-pentose, mannose and galactose etc. [18].

The purpose of the pretreatment method is to remove lignin and hemicellulose from lignocellulose material, reduce the crystallinity and increase the surface area of cellulose for the hydrolysis method [9]. Several types of pretreatment are presented such as *chemical pretreatment* that use acid, alkaline, organosolv and ozonolysis method, *physical pretreatment* such as milling, irradiation, *physical- chemical pretreatment* such as stream-explosion, $CO_2$ explosion etc. [15]. The chemical pretreatment is however the most attractive for lignin removal to improve the effective of cellulose before enzymatic hydrolysis.

From previous extensive research, diluted acid hydrolyze hemicellulose to sugar monomer rich in xylose and other inhibitory substances such as furfural and hydroxymethylfurfural that is found in pentose degradation [1, 11]. Alkaline pretreatment affects lignocellulose by dissolving the uronic and acetic acid ester of hemicellulose and lignin; moreover, cellulose can be swelled by dilute alkaline to increase surface area before enzymatic hydrolyzed [11]. Another pretreatment is organosolv using the organic solvent (low boiling point alcohol, high boiling point alcohol, organic aid and acetone etc.) in the delignification process. However, organic solvents are expensive, so a recovery unit is necessary for this pretreatment [9].

This study aims to investigate the parameters (temperature, concentration and reaction time) that affect sugar products from pretreatment and enzymatic hydrolysis by using acid pretreatment and alkaline pretreatment. The Response Surface Methodology (RSM) and Fractional Factorial Design (FFD) were applied to perform the Design of Experiment. The two – levels FFD was used to identify the significant factors from multivariable parameters together with the central point and added to estimate error in the Design of Experiment [14]. After pretreatment, the filtrate after filtration was analyzed by High Performance Liquid Chromatography (HPLC) and UV- Visible Spectrophotometer while the remained solid bagasse was measured to determine cellulose, hemicellulose, insoluble lignin and other impurity substrates. Moreover, the Analysis of Variance, (ANOVA) by using The Unscramble X version 10.3 was used to study the relationship of dependent variables (Response Variable) and one or more independent variables at the confident level above 95% ($p = 0.05$). Finally, the enzymatic hydrolysis process of pretreated bagasse is used to determine the effective of each chemical pretreatment.

## 1.2 Objectives

1. Study the effect of parameters (temperature, reaction time and concentration) on lignin removal, xylose, glucose, furfural and HMF production by using chemical pretreatment method.
2. Determine the most effective pretreatment method for lignin removal, xylose, glucose, furfural and HMF production.

## 1.3 Scope of Work

1. Design the acid/alkaline pretreatment experiment that studies the effect of temperature, concentration and reaction time on sugar production from bagasse
2. Apply the response surface methodology (RSM) method for designing the pretreatment experiment and compare the result for each chemical
3. Investigate the trend of parameters on lignin removal xylose, glucose, furfural and HMF production by using analysis of variance (ANOVA)

## 1.4 Expected Results

This study aims at finding information on following points:

1. The most effective chemical reagent with positive effects on the sugar content of the product.
2. The trend of parameter (temperature, reaction time and concentration) on sugar product.

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