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GASIFICATION OF EMPTY FRUIT BRUNCH IN MICRO FIXED BED REACTOR FOR HYDROGEN PRODUCTION

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UNIVERSITI TEKNOLOGI MALAYSIA

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GASIFICATION OF EMPTY FRUIT BRUNCH IN MICRO FIXED BED REACTOR FOR HYDROGEN PRODUCTION

MOJTABA MAZANGI

A dissertation submitted in partial fulfillment of the
requirement of the award of the degree of
Master of Engineering (Chemical)

Faculty of Chemical Engineering
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JULY 2013

I declare that this dissertation entitled “Gasification of Empty Fruit Brunch in Micro Fixed Bed Reactor for Hydrogen Production“ is the result of my own research except as cited in the references. The dissertation has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

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To my beloved family

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ABSTRACT

Providing energy for future has been a big problem considering the fossil fuel running out and high demand for energy consumption. Biomass considered the most favorable source of energy on the earth which optimize within 10 to 15% of world energy as primary source. The aim of this research is to find a new sustainable source of energy and evaluate the benefits and efficiency as well. The studies include equivalence ratio (ER), steam to biomass ratio (S/B), and temperature. The preferred ER and S/B ratio were set to 0.4 and 0.5 to 0.8 respectively, furthermore temperature profiles of 600°C to 700°C applied to investigate the effect on the experiments. The results show that beside syngas (CO and H_2), CO_2, CH_4, C_2H_4 and C_2H_6 were also generated. Only hydroxygenated compound such phenol, X and Y, were detected using Gas chromatography mass spectrometers (GCMS) in the liquid product. The H_2 content was measured in the product gases up to 50% which increased by increasing the S/B and the temperature. In addition, the amount of solid residual identified as char, and had opposite behavior compare to H_2,. The experiments achievements conclude that gasification of EFB could be a competitive method for renewable source of energy in future.

ABSTRAK

Menyediakan tenaga untuk masa hayat telah menjadi masalah besar mempertimbangkan bahan api fosil kehabisan dan permintaan tinggi untuk penggunaan tenaga. Sekarang ini fakta terbesar menyiasat dan sambungan sumber tenaga yang diperbaharui baru. Biojisim mempertimbangkan sumber yang paling bertuah tenaga di bumi yang merupakan contoh dalam 10 hingga 15% tenaga dunia sebagai sumber utama. Tujuan penyelidikan ini ialah untuk mencari satu sumber yang boleh dikekalkan baru tenaga dan menilai faedah dan kecekapan juga. Kajian termasuk nisbah kesetaraan, mengukus kepada nisbah biojisim dan suhu. ER pilihan dan S / nisbah B telah ditetapkan kepada 0.4 dan 0.5 hingga 0.8 masing-masing , tambahan pula profil suhu 600°C kepada 700°C digunakan menyiasat kesan di eksperimen. Keputusan menunjukkan itu di sebelah syngas (CO and H2), CO2, CH4, C2H4 and C2H6 juga dijana dan hidrokarbon dan sebatian hydroxygenated di hasil cecair juga. Kandungan H2 telah disukat di gas-gas produk sehingga 50% yang bertambah dengan menambahkan S / B dan suhu juga. Sebagai tambahan jumlah padu sisa dikenal pasti sebagai karbon yang mana menghanguskan , dan mempunyai bertentangan tingkah laku berbandingan H2 , di mana yang sederhana lebih rendah nilai pemanasan (LHV) mengira 8.9 MJ / Nm3. Kejayaan eksperimen-eksperimen menyimpulkan bahawa gasification of EFB mungkin adalah satu kaedah kompetitif untuk sumber tenaga yang diperbaharui pada masa depan .

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LIST OF SYMBOLS

EFB	-	Empty Fruit Bunch
PKC	-	Protein Kinase C
UTM	-	Universiti Teknologi Malaysia
CDM	-	Clean Development Mechanism
GHG	-	Green House Gases
CO_2	-	Carbon Dioxide
CO	-	Carbon Monoxide
SO_x	-	Sulfur- Oxygen Compound
NO_x	-	Nitrogen-Oxygen Compound
USA	-	United State of America
H2	-	Hydrogen
ER	-	Equivalence Ratio
S/B	-	Steam/Biomass Ratio

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CHAPTER 1

INTRODUCTION

1.1 Background of Study

Large efforts have been carried out on developing the existing technologies for biomass gasification since last decade. The technology that already used is the legacy of coal gasification which was extended widely during World War II. At that time the aforementioned technology was used to produces fuel gas for car's engines, after World War any improvement on gasification technologies has not been seen until the oil crisis on 70`s. Re-developing the technologies based on biomass potential opened a new age of gasification [1]. There are many practices (e.g. chemical, physical, thermal even biological) for converting the biomass to handle the generation of energy and fuels. It can generates electricity, heat, solid fuels (coal), liquid fuels (bio-oil, bio-methanol and bio-ethanol) and gas fuels (hydrogen and syngas) as well which the last will be considered in this study [2].

Nowadays, one of the most assuring energy sources is hydrogen which can be used for internal combustion engines and be utilized in fuel cells. However we have the limited source of hydrogen on earth. Meanwhile close to 95% of hydrogen has produced from fossil fuel that is cause of releasing a large volume of CO_2 to atmosphere. In the 1980 the global warming became one of concern point that caused increasing temperature and changes in climates by CO_2 emitted resulted consumption of fossil fuels. This concern led to Kyoto Objectives, that interest to CO_2 emission reduction, which renewed the interest on biomass [3]. As mentioned earlier, although, coal gasification and biomass gasification are too similar, the product gases are defferent for biomass and based on higher reactivity of biomass, process is moderate condition (temperature and pressure) compare to coal gasification. Furthermore achieving high concentration of hydrogen and carbon monoxide is result of increasing the temperature. Mixture of steam and air or oxygen will be used for syngas production whereas steam is gasification agent and oxygen or air help to promote the reaction. Increasing the temperature of inlet oxygen can be resulted to tar content reduction. Hydrogen production by gasifying biomass is one of the greatest achievements since the biomass abundantly is available in all over the world and it is only carbon source that is renewable, also it can be converted to hydrogen [4].

Biomass consists of organic compounds produced by the activities of living creatures which is an abundant even as domestic resource, and can be a renewable feedstock for hydrogen production [3]. Hydrogen is produced from gasification of biomass followed by its conversion into hydrogen. By reacting hydrogen with carbon monoxide (which is called syngas) in presence of specific catalyst, the product would be valuable which are naphtha, diesel oil, kerosene and etc., this reaction will places in very limited reactor and under particular conditions, such as shell middle distillate synthesis. Comparing these products with oil refinery products, resulted to supremacy of syngas over oil refinery product, based on easier transportation because of liquid phase, higher quality compared to other production methods, higher combustion efficiency in engines, friendlier with the environment and less sulfuric and aromatic compounds [5].

1.2 Problem Statement

Still the main process of hydrogen production is based on fossil sources even though it remains for next decade, however increasing of usage of hydrogen can lead to energy crisis and environmental impacts. Increasing in fossil fuel using results in carbon dioxide emissions and other greenhouse gases (GHG) and exhausting the SO_x, NO_x and aerosol which causes global warming that would be demonstrated in rising of sea levels, increasing the weather temperature and storm weather patterns [6]. Since about 150 years ago that crude oil has been extracted from reservoirs in USA, it has been refining to produce petrol, and many other type of hydrocarbonic compounds (petroleum product e.g. Plastic) so it was known as main source of energy. Nowadays oil production is being reached to its peak and we are running out of oil sources. With developing in technologies, it seems scanning and discovering new sources for oil became easier but less places will available for looking at, in addition the cost of extraction is soaring due to remote places. By increasing the fossil fuel consumption, and the variety of serious problem that can lead to, emission of carbon dioxide and other greenhouse gases that mentioned before many practices have been investigated to evaluate the new method for supply new resources for energy. Using biomass instead of fossil fuels can result in a new, clean and safe world. Apart from that, biomass is sustainable source of fuels [7].

Palm oil briquette which considered as biomass can be used as sustainable energy source. Empty Fruit Bunch (EFB) and Protein Kinase C (PKC) are compacted into uniform solid fuel called briquette. It has Briquette higher energy content with less moisture and is not consumed by locals for cooking purposes as cheaper substitutes are available. The rosier outlook lies in its future utilization as feedstock for second generation biofuel, where the entire waste biomass can be harnessed in the production of renewable energy, cellulosic ethanol, biogas, bio-hydrogen and bio-plastic.

This energy is not only cheaper but also more efficient and environment-friendly than fossil fuels. The carbon credits derived under the CDM (Clean Development Mechanism) Kyoto Protocol increase the economic viability of palm diesel as a renewable fuel [8].

1.3 Objective of Research

The main objective of this study is to evaluate the gasification of powder derived from palm oil briquette in a micro fixed bed reactor toward production of hydrogen. This objective is focused on:

i. The effect of steam to biomass ratio, and
ii. The effect of gasification temperature

1.4 Scope of Study

The studies were carried out in a micro fixed bed reactor at atmospheric pressure.

i. Characterization of the palm oil briquette powder using proximate analysis, ultimate analysis and thermogravimetric analysis.
ii. The steam to palm oil briquette powder (S/B) between 0.5 to 0.8
iii. The gasification temperature profile in a range of 600°C to 700°C

1.5 Significance of Research

Since the fossil fuel sources are limited, significance of replacing the fossil fuels with a sustainable source of energy, biomass, is considered.

Malaysia is the largest producer of palm oil in the world accounting for 41% of total global output. However, the production of palm oil generates large quantities of waste. Furthermore the transportation of the waste makes many difficulties so it should be reshaped to briquettes which are compressed and takes less places for storage and more easier for transportation.[9]

Hydrogen could be considered as sustainable and new source of energy which can be produced directly from gasification of EFB.

All previous studies used different types of biomass for gasification in fluidized bed such as; wood pallets, cellulose, manure compost, and some type of briquette but in this study new material for producing hydrogen through gasification has been chosen to be conducted in fixed-bed gasifier considering empty fruit brunch.

The hydrogen production from fossil fuels industry is one of the biggest sources that emit the huge amount of CO_2 to the atmosphere which cause many problems like global warming. Biomass has been selected as sustainable sources for producing hydrogen to reduce in CO_2 emission and greenhouse gases (GHG).

Because of low NO_x and SO_x contents, biomass were preferred to many source of energy compare to others especially to fossil fuels, and based on the gas product and structural nature of biomass gasification, it will be used as environmental friendly process. The high yield of H_2 content made it cost competitive method.

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